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## ORIGINAL ARTICLES.

### I.—Restoration of Stegosaurus.

By Prof. O. C. Marsh, Ph.D., LL.D., F.G.S., etc.

(PLATE XI.)

IN the American Journal of Science in 1877, the writer described a remarkable extinct reptile from Colorado, under the name *Stegosaurus armatus*,[1] and later a much more perfect specimen of another species, *Stegosaurus ungulatus*, from essentially the same horizon, in the Jurassic of Wyoming.[2] The latter specimen was in fine preservation, and the more important parts of the skull and skeleton, and especially of the remarkable dermal armour, were secured. Subsequently, more than twenty other specimens of these and other species were obtained, so that nearly every part of the osseous structure thus became known, and only portions of the dermal armour were in doubt. A fortunate discovery cleared away most of the doubt in regard to one species, *Stegosaurus stenops*, as the type specimen had the skull, skeleton, and dermal armour together when entombed, and almost in the position they were when the animal died.

With this rich material at hand, an attempt has been made to give a restoration of one of the group, and the type specimen of *Stegosaurus ungulatus* has been selected as the basis. This has been supplemented by a few portions of the skeleton of *Stegosaurus duplex*, apparently a closely allied species from nearly the same locality, while some other parts, especially of the dermal armour, have been placed in accordance with their known position in *Stegosaurus stenops*.

The result is given in Plate XI., which is believed to represent faithfully the main features of this remarkable reptile, as far as the skeleton and principal parts of the dermal armour are concerned. This figure, one thirtieth natural size, is reduced from a larger restoration, one-tenth natural size, made for a lithographic plate to accompany the monograph of the *Stegosauria*, prepared by the writer for the U. S. Geological Survey. When alive, the animal was about twenty feet in length, and nearly or quite twelve feet in height.

[1] American Journal of Science, III. vol. xiv. p. 513, December, 1877.

[2] *Ibid.* vol. xviii. p. 504, December, 1879. See, also, vol. xix. p. 253, March, 1880; vol. xxi. p. 167, February, 1881; and vol. xxxiv. p. 413, November, 1887.

In this restoration, the animal is represented as walking, and the position is adapted to that motion. The head and neck, the massive fore limbs, and, in fact, the whole skeleton, indicate slow locomotion on all four feet. The longer hind limbs and the powerful tail show, however, that the animal could thus support itself, as on a tripod, and this position must have been easily assumed in consequence of the massive hind quarters.

In the restoration as here presented, the dermal armour is the most striking feature, but the skeleton is almost as remarkable, and its high specialization was evidently acquired gradually as the armour itself was developed. Without the latter, many points in the skeleton would be inexplicable, and there are still a number that need explanation.

The small, elongated skull was covered in front by a horny beak. The teeth are confined to the maxillary and dentary bones, and are not visible in the figure here given. They are quite small, with compressed, fluted crowns, and indicate that the food of this animal was soft, succulent vegetation. The vertebræ are solid, and the articular faces of the centra are bi-concave or nearly flat. The ribs of the trunk are massive, and placed high above the centra, the tubercle alone being supported on the elevated diapophysis. The neural spines, especially those of the sacrum and anterior caudals, have their summits expanded to aid in supporting the massive dermal armour above them. The limb bones are solid, and this is true of every other part of the skeleton. The feet were short and massive, and the terminal phalanges of the functional toes were covered by strong hoofs. There were five well-developed digits in the fore foot, and only three in the hind foot, the first toe being rudimentary, and the fifth entirely wanting.

In life, the animal was protected by a powerful dermal armour, which served both for defence and offence. The throat was covered by a thick skin in which were imbedded a large number of rounded ossicles, as shown in the figure. The gular portion represented was found beneath the skull, so that its position in life may be regarded as definitely settled. The series of vertical plates which extended above the neck, along the back, and over two-thirds of the tail, is a most remarkable feature, which could not have been anticipated, and would hardly have been credited had not the plates themselves been found in position. The four pairs of massive spines characteristic of the present species, which were situated above the lower third of the tail, are apparently the only part of this peculiar armour used for offence. In addition to the portions of armour above mentioned, there was a pair of small plates just behind the skull, which served to protect this part of the neck. There were also, in the present species, four flat spines, which were probably in place below the tail, but as their position is somewhat in doubt, they are not represented in the present restoration.

All these plates and spines, massive and powerful as they now are, were in life protected by a thick, horny covering, which must have greatly increased their size and weight. This covering is clearly

indicated by the vascular grooves and impressions which mark the surface of both plates and spines, except their bases, which were evidently implanted in the thick skin.

The peculiar group of extinct reptiles named by the writer the *Stegosauria*, of which a typical example is represented in the present restoration, are now so well known, that a more accurate estimate of their relations to other Dinosaurs can be formed than has hitherto been possible. They are evidently a highly specialized sub-order of the great group which has the typical *Ornithopoda* as its most characteristic members, and all doubtless had a common ancestry. Another highly specialized branch of the same great order is seen in the gigantic *Ceratopsia*, of the Cretaceous, which the writer has recently investigated and made known. The skeleton of the latter group presents many interesting points of resemblance to that of the *Stegosauria*, which can hardly be the result of adaptation alone, but the wide difference in the skull and in some other parts indicates that their affinities are remote. A comparison of the present restoration with that of *Triceratops*, recently published by the writer,[1] will make the contrast between the two forms clearly evident.

All the typical members of the *Stegosauria* are from the Jurassic formation, and the type specimen used in the present restoration was found in Wyoming, in the Atlantosaurus beds of the Upper Jurassic. *Diracodon*, a genus nearly allied to *Stegosaurus*, occurs in the same horizon. *Omosaurus* of Owen, from the Jurassic of England, is the nearest European ally now known, but whether it possessed a crest of dermal plates like that of *Stegosaurus* is doubtful, although caudal spines were evidently present.

## II.—The Scandinavian Glacier, and some Inferences derived from it.

By T. F. Jamieson, F.G.S.

IT is now fifty years since Charpentier[2] told us that the heaps of Northern boulders which stretch across the plains of Prussia and Saxony mark the ancient limits of the great glacier of Scandinavia, and that the smaller debris met with farther south represents the stuff carried on by the torrents that escaped from the margin of the ice. All this he explained to his incredulous contemporaries, and now after half a century of debate, in which every other conceivable mode of accounting for the phenomena has been tried, it seems to be agreed on all hands that he was right—right in every particular—but, strange to say, it appears to be now generally forgotten that he was the man to whom we owe the first sketch of this explanation.

Agassiz,[3] in 1846, alluding to the previous observations of Charpentier, candidly said, "I was unable to believe in his conclusions when he first imparted them to me, and I made observations in order

[1] See Geol. Mag. Dec. III. Vol. VII. 1890, Pl. I. pp. 1–5, and Vol. VIII. 1891, pp. 193–199, Pls. IV. and V., and pp. 241–250, Pl. VII.; and Amer. Journ. of Science, vol. xli. p. 339, April, 1891.

[2] Essai sur les Glaciers, note to p. 319.

[3] Bull. Geol. Soc. France, 2 ser. iii. p. 420, 6 April, 1846.

to combat them, but I have been converted to his mode of view." Charpentier, however, tells us that it was his friend Venetz who was the first to perceive (as he tersely puts it) that "tout le phénomène du terrain erratique trouvait son explication dans l'existence ancienne d'immenses glaciers."

When the Scandinavian Glacier reached its maximum, it extended over most of Northern Europe and stretched eastward beyond Moscow. To the south-east it went as far as the 50th parallel of lat. on the banks of the Dnieper, and from that its southern border ran westward along the northern base of the Carpathian Mountains and the hills of Central Germany to the mouth of the Rhine. If the starting-point lay in the mountain-chain of Scandinavia, the ice must have travelled to the south-east, a distance of fully 1000 miles. Nitikin[1] tells us that the northern erratics extend over the whole Government of Tschernigow and the east part of that of Kiew, but the unstratified brown Boulder-clay which accompanies them does not go beyond the eastern border of the Tschernigow Government.

General Helmersen[2] says that heaps of northern boulders, generally of small size, but some of them four feet in length, occur as far as Moscow, while further south they rapidly diminish in size to mere pebbles. The large angular blocks mentioned as occurring in the Governments of Kursk and Woronesh are not erratics, but consist of sandstone the same as that of the district in which they are found. The size of the erratics diminishes gradually with the distance from their source. In Finland they are often as big as cottages, and in the Government of St. Petersburg blocks of large dimensions may also be seen. Most of them are of granite and gneiss, such as occur in Finland and Northern Norway.

Judging from the accounts of Torell, De Geer, and other Swedish geologists, the stream of ice that came down the Baltic must have had a length equal to fifteen degrees of latitude, or more, and the whole tenor of the evidence leads me to think that I am not overstating, when I say that the Scandinavian glacier travelled in some directions at least 1000 miles. The reason why it went so far to the south-east no doubt was because there were neither hills nor opposing glaciers to obstruct its march, and the plains of Russia gave ample room for it to spread freely onwards. The Canadian ice seems to have travelled nearly as far in a south-westerly direction, and for similar reasons.

Now what would be the inclination or slope of the surface in a glacier of such dimensions? The nearest thing of the kind that we have any knowledge about is the ice-sheet of Greenland. What the average slope of its surface amounts to has not yet been properly determined, but from all we have hitherto learned it does not seem to be less than half a degree, or 46 feet per mile. In the glaciers of

[1] S. Nitikin, Die grenze der Gletscher spuren in Russland und dem Ural Gebirge, Peterm. Geog. Mit. 1886; also Geol. Bau der Eisenbahn linie, Gomel Briansk, Russia, 1887.

[2] G. V. Helmersen, Studien über die Wanderblocke und die Diluvial Gebilde Russlands, Mem. de l'Acad. Imp. des Sci. St. Petersburg, 1869.

the Swiss Alps the smallest mean inclination is 3° or six times greater.

Nordenskiold's Expedition, in 1883, in lat. 68°, was alleged to have penetrated 160 miles into the interior of Greenland, at which distance an altitude of 6000 feet was said to have been attained. This would give an average rise of 37½ feet per mile over the whole distance; but I suspect these figures cannot be relied upon, because we are told the last 115 miles were done by the Laplanders of the party, whose estimate of the distance seems to have depended on mere conjecture. Nordenskiold himself attained a distance of only 62 miles from the outer edge, at which point he made the altitude to be 4500 feet or 72½ feet per mile. The positions of his camp were determined by solar observations, the other distances by pedometers, while the heights seem to have been fixed by the barometer. How the Lapps estimated the height they reached I have been unable to ascertain.

Dr. Hayes, who believed that he penetrated 70 miles into the interior of Greenland, found that the surface of the ice had a slope at first of about 6°, and then diminished gradually to 2° at the end of the first 30 miles. At 70 miles from the coast he calculated that he had attained an altitude of 5000 feet, which would give about 71 feet per mile, and this is almost the same result as that obtained by Nordenskiold himself. Dr. Nansen states that, in 1886, an American, R. E. Peary, travelled 100 miles from the edge of the iceblink, his highest elevation being 7525 feet. This was further north than Nordenskiold's route in 1883, and gives 75 feet per mile.

Nansen and his party, in 1888, landed on the east coast of Greenland at lat. 61° 30′, and then travelled along the coast northward to Umiavik, lat. 64° 30′. From this, after penetrating ten miles into the interior, they reached a height of 3000 feet. In lat. 64° 50′, at 40 miles from the coast, they were at a height of about 7000 feet on the 27th of August. By the beginning of September they got to a flat extensive plateau, whose height was 8000 or 9000 feet, and which seemed to rise considerably higher to the north. Over this plateau they travelled for more than two weeks, reaching the west coast in lat. 64° 12′ on the 26th September. The breadth of Greenland where Nansen crossed it in lat. 64½° does not seem to exceed 340 English miles, which would make the central point 170 miles from the coast, and taking the altitude at the centre to be 8500 feet, this would give an average slope of just 50 feet per mile. Nansen's results probably afford the best approximation we have yet got, as the fact of his crossing the whole breadth of the land in an ascertained latitude enables us to gauge the extreme distance he penetrated into the interior with some confidence, if our maps are at all correct. Further north the greatest width of Greenland seems to be about 700 miles, which would make the middle point 350 from the coast. A rise of 50 feet per mile on this distance would give 17,500 feet for the altitude of the surface at the centre.

From all we know of the Greenland ice it would seem that the

gradient of its surface increases always towards the outer edge, and that for the first hundred miles from the border we would not be justified in assuming an average slope of less than 60 feet per mile, and probably 70 would be nearer the truth. Then for the remainder of the distance suppose we put the slope as low as even 12 feet per mile, we still get the following result for a distance of 1000 miles,

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|---|---|---|---|---|---|
| 100 | miles at | 60 | feet per | mile | 6,000 feet. |
| 900 | ,, | 12 | ,, | ,, | 10,800 ,, |
| 1000 | miles. | | | | 16,800 feet. |

which gives an average of nearly 17 feet per mile over the whole length, and I see no reason for thinking a less slope at all probable. Now the present culminating point of Scandinavia is 8544 feet, and only a very few of the mountain tops exceed 6000 feet; we have therefore a very strong presumption that the former height of that land must have been vastly greater than it is now, and the same conclusion will apply to the centres of glaciation in Canada and Scotland. Supposing that in Scandinavia we place the centre of radiation for the ice not in the Norwegian hills, but in the lower ground to the eastward, still it will not materially affect the result, for although we thereby shorten the length of the glacier, we lower the present altitude of the point from which it had to start. The probability, therefore, seems to be very great that at the commencement of the Glacial period the altitude of Scandinavia was higher—very much higher—than at present, and this conclusion is strongly supported by other considerations of scarcely less weight.

1. In the first place the whole sea-board of Norway is intersected by long deep fjords, which have all the appearance of being the sunken valleys of a submerged mountain-land that had been deeply cut by rivers at a time when the country stood at a far greater height above the sea. Christiania Fjord reaches a depth of 1380 feet, Hardanger 2624, and Sogne Fjord no less than 4080 feet. Their sides are often very precipitous, and Sexe[1] tells us that in the Hardanger Fjord, in fine calm weather, when the water is very transparent, the head turns quite giddy on looking over the side of a boat down these submarine cliffs. Probably few will believe that glaciers could have eroded the hard crystalline rocks of Norway to a depth of thousands of feet beneath the sea-level, or could have cut them into such precipitous forms, for the action of a glacier on its bed has a tendency to produce flowing or bowl-shaped outlines. Moreover, the heaviest current of ice seems to have been that which came down the Baltic, which is a shallow sea, the general depth being only 40 to 60 fathoms. The probability, therefore, seems to be that these fjords of Norway, like the cañon of Colorado, were cut by mountain-streams in pre-Glacial times when the land stood at a much greater height, for how otherwise can we suppose them to have been excavated? The same observation will apply to the sea-lochs which indent the west coast of Scotland and also to the fjord latitudes of America, as Dana long ago pointed out.

[1] S. A. Sexe, Mœrker, efter en Iistid i omegnen af Hardangerfjorden. Christiania, 1866.

2. Again, Dr. Tyndall reminds us that what we most want in order to produce the glaciers of the Ice-time is improved condensers. Now there is no better condenser that a lofty mountain. Heave it high enough and you will get snow at the Equator, as we see on the Andes, and at Kilima-Njaro in Africa. Here then we have another good argument for a much greater height of the Scandinavian plateau, and the same observation will hold good for other glaciated regions. I therefore think that at the commencement of the Ice-time these countries had a far greater altitude than at present—an opinion which I expressed quite as distinctly thirty years ago.[1] It is difficult, indeed, to see how otherwise a sufficient permanent condensing power could have been sustained in these latitudes; for even in Greenland, at the present day, the line of perpetual snow is 2000 feet above the sea-level, and it is on the high mountain range of the interior that the ice is generated. Dr. Croll,[2] in his paper on the Antarctic ice, asserted that "the Greenland ice-sheet, like the Antarctic, must be thickest at the centre of dispersion and thinnest at the edge." If the ice lay upon a perfectly flat horizontal plane, no doubt it would require to be thickest at the centre, but if the ground supporting it is 10,000 or 15,000 feet higher at the centre than at the edge, as seems not unlikely, then the thickness at the centre of dispersion need not be so very great. If Croll had said that the surface of the ice-sheet must be *highest* at the centre and *lowest* at the edge, it would have been all very well; but the thickness of the ice at the centre of dispersion must depend much upon the altitude of the surface on which the ice rests.

As the ice accumulated upon these lofty regions they appear to have gradually undergone a movement of depression, and the opinion seems to be gaining ground that this depression may have been caused by the weight of ice which was laid upon them.[3] It is at any rate quite clear that after the period of maximum glaciation Scandinavia underwent a partial submergence, during which the great glacier seems to have broken up and disappeared from much of the ground it once covered, and this same order of events seems to have occurred in the other great centres of glaciation in Britain and North America.

Dr. Penck's[4] theory that the submergence was caused by attraction of the ice drawing the sea up on to the land, has not been sustained by an appeal to mathematical investigation; for Woodward in America, Drygalskí, and Hergesell in Germany, and Faye in France, who have in elaborate papers discussed the subject from a mathematical point of view, seem all to agree that the cause in question would be quite insufficient to account for the facts, even on the most liberal estimate of the possible volume of ice. Indeed, it would

[1] Quart. Journ. Geol. Soc. vol. xviii. p. 180–1, Feb. 1862.
[2] Quart. Journ. of Science, Jan. 1879.
[3] G. de Geer, Om Skandinaviens Nivåförändringar under Quartärperioden. Stockholm, 1890. Warren Upham, Review of the Quaternary Era, Amer. Journ. of Science, Jan. 1891.
[4] Schwankungen des Meeresspiegels, Jahrb. der Geog. Ges. zu Munchen, bd. vii. 1882.

appear that, owing to the abstraction of water required to form the ice, the surface of the sea would on the whole be lowered, and this effect would surpass the other, however great the thickness of ice, so that the combined effect of the European and North American glaciations, if simultaneous, would be to cause a general sinking of the sea-level during the period of maximum ice. The general result, however, would depend much upon the relative extent of the Arctic and Antarctic glaciers at the time, a subject regarding which we know little or nothing. Penck seems to have been under the impression that the attraction would have caused the sea to rise towards the border of the ice in a comparatively rapid swell, but such would not have been the case. Any rise in the level of the sea induced by such a cause would be nearly parallel to the present surface, and would extend much further horizontally outwards than Penck seems to have contemplated, while its vertical extent would be far less than he supposed.

If at the commencement of the Glacial period, Scandinavia (or at least a large part of it) stood several thousand feet higher than it does now, then it follows that the subsequent depression must have been very considerable indeed, and the subsidence of such a large area to the extent required would no doubt occasion much squeezing, disturbance, and probably some upheaval in neighbouring regions. I am inclined to think that the ice was gathering on the mountains of Norway at a much earlier period than is generally believed, and that the coming on of the glaciation took place in early Pliocene times, or even sooner. Many of the disturbances that have taken place in the strata near the Straits of Dover and elsewhere may have been occasioned by strains induced by the load of ice, and the bursting out of volcanoes in Germany, Auvergne, and other places may have arisen from pressure on the subterranean lava due to the same cause.

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## III.—Transverse Valleys in the Eastern Caucasus.

By Professor Hjalmar Sjögren,
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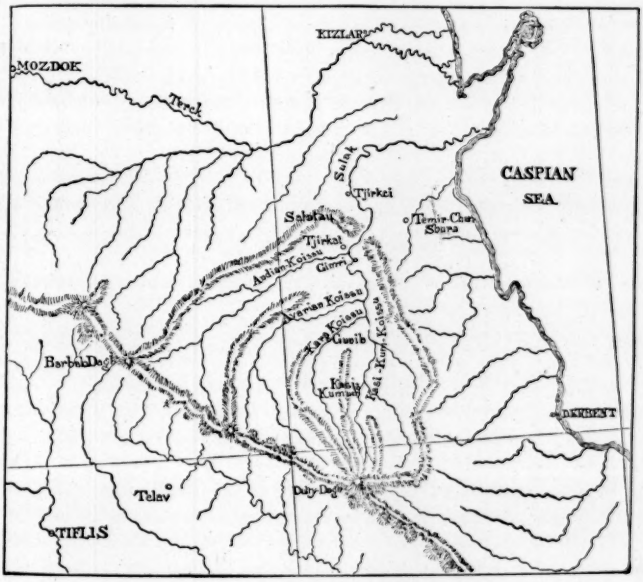
### 1. *The Sulak gorge below Gimri in Daghestan.*

Among the many valleys of Daghestan that are interesting to the geologist there are none more remarkable than the channel by which the river Sulak passes through the chain of Cretaceous and Jurassic mountains which borders Inner Daghestan. Just above the entrance of this defile the four rivers Koissu unite in one stream, which in a series of cataracts tears through a stupendous chasm some fifteen miles in length, cutting the huge ridge almost at right angles to its axis.

The gorge traverses the main chalk ridge in the direction N. 40° E., then changes its line to N.W., which it still follows at the widening of the valley below Tjirkei, and finally comes back to due N. as it passes through the Tertiary hills below Subut. The mean height of the ridge thus cut asunder is some 2000 mètres or more

than 6500 feet; in the summit of Salatau, which lies about three miles from the gorge, it reaches nearly 8000 feet; the bed of the river Sulak at its entrance below Gimri is about 1000 feet and at its exit near Tjirkei about 600 feet above the sea. The huge cutting has therefore a vertical depth of from 5000 to 6000 feet, while its breadth is so small that the river leaves no room for a proper road, and scarcely enough for a narrow horse-path, which is itself impassable at certain seasons of the year. The walls of the defile, which mainly consist of a compact dolomitic limestone and show the lines of stratification with unusual distinctness, rise almost perpendicularly into the air and are altogether unscalable. For this reason the valley of the Sulak, which forms a hydrographic link between Inner and Outer Daghestan, is as a means of communication between the two divisions of the province of no significance whatever. The road between Temir Chan Schura and Gimri is carried over the 6000 feet to which the intervening range of mountains here rises instead of being taken through the river gorge. This circumstance is sufficiently indicative of the wildness and inaccessibility of this transverse valley.

Before going farther, I had perhaps better give a short sketch of the orographical structure and hydrography of Daghestan.




Sketch-map of Daghestan, N. Caucasus.

Daghestan lies entirely on the N. slope of the main chain of the Caucasus, though for administrative purposes it is included in Transcaucasia. A reason for this arrangement may be found in the fact that the province is bounded on the N. also by a continuous range

of mountains, the peaks of which rise to a height of 8000 or 9000 feet. The main chain of the Caucasus, where it forms the southern boundary of Daghestan, runs in a straight line W. 28° S., while the northern ridge I have just spoken of forms a regular curve, branching off from the other at Barbalo-Dagh and joining it again at Dulty-Dagh. (See Sketch-Map, p. 393.)

The tract of country included between these two ridges is Inner Daghestan. Outer Daghestan is the tract which lies on the outer slope of the more northerly of the two ridges, and which therefore looks towards the Terak Steppe on the N. and the Caspian Sea on the N.E. Inner Daghestan may also be described as the basin of the four rivers Koissu. Surrounded as it is on every side by lofty mountains, this region would be altogether without an outlet for its waters, had not the combined streams of Koissu, which after their junction bear the name of Sulak, found a way to the Caspian Sea through the defile which we are now considering. This narrow gorge is the only channel for the drainage of an area of nearly 5000 square miles.

The physiographical character of these two regions, Inner and Outer Daghestan, is very different. Outer Daghestan consists almost entirely of Tertiary formations, Palæogene (probably Eocene) clay-slates and sandstones, Sarmatian limestones, etc. It is only in the crests of the anticlinal folds that the Cretaceous rocks here and there appear. The strata of this region lie in gentle gradients as a rule, and there are no dips exceeding 45°. The slope towards the Terek Steppe and the Caspian Sea consists of terrace-like plateaux or undulating highlands of a mean height of some 1300 feet, only the branches and outgrowths of the mountain-chain behind reaching a greater elevation.

The character of Inner Daghestan is altogether different. Here, as Abich pointed out years ago, Tertiary formations are entirely wanting. The fundamental rock is exclusively Cretaceous or Jurassic with the exception of certain of the earliest Caucasian schists, the age of which is as yet unknown.

Inner Daghestan again may be divided into two sections, as I have already suggested in my paper "Uebersicht der Geologie Daghestans und des Terek-Gebietes."[1] The lower section consists mainly of limestones and dolomites belonging to the youngest Jurassic and oldest Cretaceous periods, *i.e.* Malm and Neocomian. These formations form extensive and high-lying basin-like plateaux, which often end in precipitous, almost perpendicular, cliffs. It is only in the deep and narrow river-gorges that the schists of the middle Jurassic period come into view. Among these plateaux are that of Keher, lying between the Kara-Koissu and the Kumuch-Koissu, and reaching its highest point in Turtji-Dagh (7950 feet); that of Gunib between the Kara-Koissu and the Avarian Koissu, the highest point of which reaches some 7770 feet; and that of Kunsach between the Avarian and the Andian Koissus, of which the Talokol range (8980 feet) may be looked upon as the southern edge. The

[1] Jahrbuch der k. k. geolog. Reichsanstalt," vol. 39, p. 417 (1889).

southern faces of these huge plateaux, all of which look towards the main Caucasian chain, lie almost in a straight line with a W. 25° N. direction, a line which marks the boundary, so important in physiographical respects, between the upper and lower sections of Inner Daghestan. While the average height of these plateaux is about 6250 feet, the average height of the river beds which traverse them is not more than some 2000 feet. To this great difference of elevation is due the great difference between the climate and products of the deep valleys and those of the high plateaux in this region.

The physiographical nature of the upper section of Inner Daghestan shows a striking contrast to this. Here there are no solid strata of limestone and dolomite, but only loose schists with subordinate beds of sandstone belonging to the Lias formation or the fundamental Caucasian schists. The high-lying plateaux, with their precipitous cliffs, are no longer to be seen; the river-valleys are broader and more practicable; the mountains slope less abruptly, and their sides are modelled more softly by the ramifications of the lines of erosion.

We will now proceed to examine the structure of the chain of mountains which encloses Inner Daghestan to the N. and N.E., and give our special attention to that section through which the Sulak has found a passage.

On the whole the structure of the dividing ridge is very simple, and for the greater part of its length it may be considered as an oblique anticlinal fold or a system of several such folds. This at least is its nature for a length of some 70 miles, from Bozrach in the W. to Suluch-Dagh in the E. Throughout this stretch the ridge, which consists entirely of Cretaceous rocks, forms a boundary as well as a watershed between Inner and Outer Daghestan, and has a mean elevation of nearly 6000 feet. The steeper side of the fold lies throughout inside, *i.e.* it faces S. and S.W., while the strata of the outer slopes show a gentler angle. A marked feature of this particular section of the whole ridge is that the compression of the fold has been more violent than in the adjacent sections, where there has been less disturbance of the stratification.

I may here repeat a passage from another paper of mine which refers to the same region.[1] "I have already shown, when treating of the Cretaceous region of Daghestan, that the boundary between the Outer and Inner divisions of the province is formed by a huge ridge which belongs chiefly to the Senonian, though towards the west the Neocomian also comes in. This watershed throughout a great part of its length consists of an oblique fold. On the outer slope the strata fall gently in angles of from 10° to 20°, on the inner slope steeply, reaching from 60° to 90°."

On the eastern slope of Salatau, immediately above the transverse valley of the Sulak, the mountain is seen to be composed of three of these oblique folds, lying one above the other.

[1] "Uebersicht der Geologie Daghestans und des Terek-Gebietes." Jahrb. d. k. k. geol. Reichsanst. vol. 39, p. 434 (1889).

From the above short sketch of the main orographical features of Daghestan, we will proceed to trace the course of the four rivers Koissu, a survey of which will help to give the reader a clear notion of the conditions under which the transverse valley we are now considering was formed.

The most westerly, and at the same time the largest, of these four streams, the Andian Koissu, passes first through the deep valleys in the fundamental schists which divide the Katju range of mountains from the main chain, and so far its course is entirely longitudinal. The channel then bends to the N.E., and soon assumes a transversal character, the valley traversing a plicated region of fundamental schists and Lias, and at Konada passing into a tract of folded Jurassic and Cretaceous rocks. In its lower section the channel is alternately longitudinal and transversal; in some places it cuts obliquely through huge folds of Jurassic and Cretaceous strata (Malm to Senonian), while at others it runs parallel with them.

The two middle streams of the four, the Avarian Koissu and the Kara-Koissu, have both eminently transversal courses, as is shown indeed by their general N.N.E. direction, which is at right angles to the prevailing strike-line of the stratification. In their upper and intermediate sections these rivers flow over the fundamental schists and form wide open valleys thickly set with hamlets. But as soon as they enter the Jurassic and Cretaceous formations these valleys become so constricted that they are scarcely habitable. This is especially the case with the Kara-Koissu, the lower portion of which, from Gunib, which is the centre of the government of the district, forms a barren gorge cut in the plateaux of Malm-dolomite and Neocomian limestone. Its only inhabited points are the military stations at the bridges of Gunib and Salti. After this there is no change of direction, as the river continues to cut at right angles through the huge Malm and Neocomian formations, its channel separating the plateaux of Gunib and Salti, which would otherwise form an unbroken whole, and the mountains of Sochtala from those of Koppa.

Much the same state of things is to be seen in the course of the Avarian Koissu, though its valley is not so narrow and impracticable as that of its fellow river. It enters the flat Cretaceous and Jurassic folds at a small angle, and then below Kara-Dagh traverses them perpendicularly.

The most easterly of the four branches, the Kumuch-Koissu, in its upper course from Chosrek to Kasi-Kumuch, the centre of the local government, has a N. 25° W. direction, which corresponds with the general strike of the schists and sandstones over which it passes. On both sides of the valley the strata fall to the E.S.E., the character thus being that of an isoclinal valley. Lower down, near Kumuch, where the river-channel enters the Jurassic and Cretaceous strata, it partly cuts through the huge folds at a sharp angle and partly runs parallel with them.

If we now shortly summarize what I have just said, we shall see that the four rivers Koissu have on the whole a course which

traverses the prevailing strike of the stratification, and in their upper valleys flow over soft and unresisting schists of Lias and earlier formations. They then enter a region of folded Jurassic and Cretaceous strata, where they cut through a plateau of synclinal character, the mean height of which is 6250 feet, while the river beds reach no more than some 2000 feet. Still further down, below Gimri, the four streams unite at a height of about 1100 feet, and then, as the Sulak, pass through a range of mountains which reach more than 6500 feet in mean elevation.

For these phenomena I can find no explanation so well supported by the data at hand as the hypothesis that the bed of the Koissu rivers and the Sulak originally lay at so high a level that the water flowed over the great range of mountains without cutting it, and that the transverse valley which now exists was subsequently eroded to its present depth, its erosion keeping pace with the general denudation of the valleys which lay behind. I came to this conclusion when I was travelling in Daghestan in 1888, though I had then given no special attention to the general question of transverse valleys. After my return I was induced to study the subject more closely, and I then discovered that the same or similar hypotheses had been advanced long before.

If we apply this theory to the special case which we are considering, we shall soon see how these rivers in their upper channels, where they flow over soft and easily destructible beds of schist, have managed to hollow out the wide open valleys which there occur, while in the solid and compact limestones and dolomites of the lower part of Inner Daghestan, they have only been able to produce deep narrow cuttings with precipitous walls. General denudation has reduced the level of the upper schist region, till its elevation has become less than that of the limestone and dolomite plateaux and that of the great mountain ridge, all of which once lay below it. The same explanation which serves for the Sulak gorge below Gimri will apply to the narrow defiles at Gunib and Salti in the lower course of the Kara-Koissu, and they may also be regarded as true transverse valleys.

But the whole of the valley system will be still clearer to us if we consider its original history and gradual development.

It was probably at the beginning of the Tertiary period that Inner Daghestan rose above the sea and became dry land. I have already drawn attention to the important fact that there are no Tertiary formations in Inner Daghestan, for which reason we must suppose that this region already lay above the sea, whereas Outer Daghestan consists mainly of formations of this period. On the other hand we find in the lower part of Inner Daghestan among the Jurassic folds remains of Gault and Aptian (Middle and Lower Greensands) which show that the sea of the Cretaceous period covered at least a part of this region. This is also proved by the enormous Senonian deposits which form the dividing ridge between Outer and Inner Daghestan and show a thickness of more than 3000 feet. At the beginning of the Tertiary period, however, it was probably this

ridge that formed the limit of the land, and its outer slopes, which look to the N. and N.E., would in that case have been washed by the Tertiary sea.

As soon as Inner Daghestan rose above the sea the work of erosion must have begun. At that time there would have been no river valleys or lines of erosion in the comparatively smooth surface of the country, and the drainage would have followed the general slope to the N. and N.E. To this period we must assign the origin of the valley-system which the Koissu rivers now follow, and it is easy to see how, on the then smooth and featureless surface, the channels could show such independence of the geological structure of the subjacent rocks as we have seen is actually the case.

During the long geological periods that have since elapsed, this region has been exposed to many and great changes. Subterranean forces have raised the whole mountain system of the Caucasus; the forces of denudation have at the same time from prominent points stripped off whole masses of strata and displayed the older formations which lay beneath. Throughout all these changes, however, the Koissu rivers have retained their original course, owing to the fact that the erosion of their channels has kept pace with operations which have threatened to divert them. Just as general denudation has lowered the level of the country which formed their upper basin, so and in a corresponding degree has erosion deepened the narrow defile in which they pass through the barriers of Jurassic and Cretaceous folds, and has produced the present state of things which at first sight strikes us as so abnormal.

This explanation is the same that Penck, in his review of theories to account for transverse valleys, has characterized by the term "Geologische Gefällsthäler,"[1] or valleys which are due to intense denudation in their upper sections. The first to apply the explanation was Gümbel, in the special case of Altmühl in Bavaria. At about the same time and quite independently similar hypotheses were advanced by Jukes and other English geologists to explain similar phenomena in England and Ireland.

These transverse valleys have the important and characteristic feature that their rivers pass from the older formations which lie at their sources on to strata of newer and newer date. The later strata upon which such a river enters in the lower portion of its course were no doubt once present in the region about its source. This region lay, when the river began to run, higher than those tracts through which it now passes further down, but now, owing to excessive denudation of the upper basin, the conditions are just the opposite.

### 2. *The Gerdiman-tschaj gorge below Lagitsch.*

A precisely similar origin must be assigned to the fine transverse valleys in which the Gerdiman-tschaj, after flowing through the cauldron-like valley of Lagitsch on the southern side of the main

[1] "Die bildung der Durchbruchthäler," Schriften des Vereines zur Verbreitung naturwissenschaftlicher Kenntnisse in Wien, vol. 28, p. 433 (1888).

Caucasian chain, passes the Lagitsch range, which on the eastern side of the gorge has the name of Nial-Dagh, on the western that of Elgja-Duk. In point of volume the Gerdiman-tschaj river is insignificant compared with the Sulak, but the natural cutting made by it to the south of Lagitsch is little inferior in grandeur to that through which the larger river passes near Gimri.

In order to make clear the topography and geological structure of the Lagitsch valley and the surrounding mountains, I reproduce the following from an earlier paper of mine: "Bericht über einen Ausflug in den südöstlichen Theil des Kaukasus in Oktober und November, 1889." [1]

The Lagitsch valley-system consists of two separate branches, of which the larger and more easterly is the channel of the main river Gerdiman-tschaj, while the smaller, which lies to the west, carries a tributary stream. The two are separated by a mountain ridge running N. and S. and reaching a mean elevation of some 6000 feet. The minor valley forms an almost circular cauldron about six miles across, at the bottom of which lie the villages of Dachar and Wascha. The main valley on the other hand is long and narrow, and may be divided into two sections, of which the upper, running from N.W. to S.E., begins on the slope of Baba-Dagh, while the lower, which runs nearly N. and S., may be said to end with the beginning of the Gerdiman-tschaj defile. Both valleys are separated by high ridges of about 7200 feet from the Pyrsagat valley-system on the E., and from that of Gök-tschaj on the W. On the N. the Lagitsch valleys are bounded by the main range of the Caucasus, which just here rises with excessive abruptness, and reaches its highest point in Baba-Dagh, a peak of 11,940 feet.

The only opening in the mountains enclosing the Lagitsch valleys lies to the S. Here, through the transverse cutting with which we are now concerned, the Gerdiman-tschaj passes a mass of mountain composed of basalts, tuffs, and limestones raised to an almost vertical position. Owing to the comparative impracticability of the gorge, where the encroachments of high-water prevent the construction of a good road, it is only at intervals that a regular communication between the country above and below can be kept up. The most convenient link of connexion is the road which goes to the E. over the pass of Machtokjan-gjadu (7090 feet) to the Pyrsagat valley.

At the entrance of the gorge, a mile or so below the village of Lagitsch, the bed of the Gerdiman-tschaj has an elevation of about 3430 feet. As the ranges of Nial-Dagh and Elgja-Duk, which lie on either side, reach heights of 6900 feet and 7600 feet respectively, it follows that this transverse valley has a vertical depth of more than 3800 feet.

In respect to their geological structure the Lagitsch valleys consist of a huge stratified series of clay-slates, which are to a great extent ferruginous, and thinly laminated limestones, which are impure, compact and often half crystalline. As there are no fossils in these beds,—I have only found in some of the clay-slates doubtful

[1] Mittheilungen d. k. k. geographischen Gesellschaft in Wien, 1890, p. 153.

fucoid impressions—the geological position of the whole complex can only be determined indirectly. The petrographic features remind one strongly of the Eocene formations in the Eastern Caucasus, and the superposition upon limestone in the case of Nial-Dagh is analogous to the superposition on Senonian white chalk in the other instance. Moreover, the occurrence of strongly ferruginous clay-slates both to the N. and S. of the eastern Caucasus is especially characteristic of the Eocene period. At the northernmost end of the two valleys, on the side of Baba-Dagh itself, there are thinly laminated limestones raised at considerable angles.

We will now turn to the structure of the ridge of mountains which the channel of the Gerdiman-tschaj enters as it leaves the Lagitsch valley. This ridge I have myself crossed on the way from Mudschi, a village on the S.E. side, over to Lagitsch, as well as by the route through the Gerdiman-tschaj gorge, in which the stratification is very finely displayed. Regarded as a whole, the Nial-Dagh ridge consists of a colossal fold leaning over towards the S. and is mainly composed of limestones and stratified eruptive tuffs. If we look to the details we see that massive eruptive rocks, with the character of basalt and andesite, also enter into the composition of the ridge.

It must still be left an open question whether these eruptives occur as dykes in the stratification or formed beds originally.

As one ascends the slopes of Nial-Dagh from Mudschi, one passes across a series of zones, which in petrographical respects differ from each other distinctly. The series is as follows, beginning from below:—

1. Compact grey thin-bedded limestones, together with light grey crystalline thick-bedded limestones, both of these alternating with soft stratified tuffs, which are often much weathered.
2. Eruptives varying from dark grey to a greyish-green together with the accompanying tuffs, the first forming compact rocks of andesitic and basaltic character, which often split spheroidally, the latter being foliated or thinly bedded.
3. Dark grey shaly tuffs together with conglomerates and pudding-stones; the pebbles of eruptive material or limestone; the matrix calcareous or tuff-like.
4. Light grey crystalline limestones in thick beds, with greyish green shaly and much weathered tuffs.
5. Dark clay-slates, sometimes with green calcareous layers intervening; in some of the conglomerate beds green grains are abundantly distributed and probably come from disintegrated eruptive material.
6. Light grey limestones and greyish green tuffs, as in 4.
7. Thinly-laminated clay-slates, sometimes strongly ferruginous, in thin, reddish brown, sandstone-like beds, and with numerous veins of calc-spar.

The whole of this complex of strata reaches a thickness of some 8250 feet. In 1 the dip was 65°–70° N.N.E., and the strike N. 60° W.; in 4 the dip was 62°–65° N.E., while the strike lay N. 45° E. At the pass (6600 feet) the strata of 7 stood vertically.

I will now shortly state the observations I made during the passage of the Gerdiman-tschaj gorge. The direction is N.E. to S.W., the length about five miles, and to the S.W. the defile increases in width, while the mountains decrease in height.

At the entrance of the gorge, a little S. of Lagitsch, come first the same clay-slates which occupy the greater part of the Lagitsch

valley; here the strata dip sharply towards the N. Then come two thick systems of strata, standing almost vertically, and consisting of light half-crystalline limestones, which correspond to the two sections 4 and 6 in the above Nial-Dagh profile, and are separated by a series of clay-slates (section 5 in the preceding profile). One then passes some dark, shaly, and often tuff-like strata, corresponding to section 3, and enters a zone of massive basalts and andesites, answering to section 2 in Nial-Dagh. So far there is complete correspondence with the Nial-Dagh profile, though there the eruptives appear only once, while in the S. portion of the river gorge they form three several divisions of the profile. Between the first and second masses of basalt, reckoned from the N., is a narrow, closely compressed fold of limestone, which has both its limbs dipping isoclinally to the N., and is encased in a mantle of slate. The second and third masses of basalt are separated by thick compound folds of slate, which have a general dip to the N.

If we now summarise the facts that I have adduced as to the geological structure of the various parts of the Gerdiman-tschaj valley, we see that the upper basin of the river on the S. slope of Baba-Dagh consists of hard and compact rocks, but that shortly afterwards the channel passes into the looser-slate of the Lagitsch region, where an open cauldron-like valley has been formed by erosion. On entering the hard limestones and eruptive rocks of the mountain ridge now barring its way, the river has had its channel again constricted to a narrow cleft, as erosion has here been unable to do more than maintain a narrow furrow, at a level which has kept pace with the continual sinking of its upper basin by ordinary denudation.

Our consideration of this valley will thus lead us to the same conclusion that we arrived at in the case of the Sulak. Originally the river bed lay at a much higher level and passed over the ridge of Nial-Dagh instead of cutting through it. Subsequently the wide Lagitsch valley has been hollowed out by the denudation of the loose, soft slates in which it lies. With this denudation and consequent sinking of level the river-erosion which went on below, on the Nial-Dagh section, has been able to keep pace, and the stream, working, so to say, after the manner of a saw, has cut a deep groove through the mountain ridge of hard and compact rocks.

It is well worthy of notice that the river has chosen a point in the ridge where for the sake of a channel it had to cut through three huge columns of basalt and where the work of erosion must have been considerably more difficult than farther east. This fact is in full agreement with the circumstance that transverse valleys of this kind, as is shown by observations elsewhere, often cut their way through some mass or column of hard rock which could easily have been circumvented. This should be a proof that such channels have originally passed at a far higher level, when the obstacle in question was absent, and that they have since contrived in spite of it to pursue the course they had once adopted.

The Gerdiman-tschaj shows us well that the rule of permanence of

channel holds good, not only in the case of large and deep rivers, but also in the case of so comparatively insignificant a stream as this, which at certain seasons of the year runs almost dry and has so trifling a volume of water that it disappears completely in the Kura Steppe without reaching either river or lake of any kind. And yet this small volume of water has been able to execute so grand a piece of erosive work.

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## IV.—On the Sands and Gravels Intercalated in the Boulder-clay.

By G. W. Bulman, M.A., B.Sc., Corbridge-on-Tyne.

(*Concluded from the August Number*, p. 348.)

On the Italian side of the Alps a similar set of lignite beds occurs as on the Swiss side. But these Italian lignites, although occurring *beneath*, are not *underlaid* by glacial deposits.

Evidently, then, they afford even less evidence of an interglacial period than those on the Swiss side; and this Prof. Geikie himself seems to confess; for he writes of them:

"They are clearly of older date than any recognizable morainic or diluvial deposits in Northern Italy; and if it were simply a question of local geology, one could have no good reason for doubting their pre-glacial age." [1]

And yet, taking them along with the Swiss beds, he finds in them similar witness to an interglacial period.

With regard to the "marine sands" with which the lignites seem to be contemporaneous, Prof. Geikie considers the evidence of their fossil shells insufficient to establish their pre-glacial age.

The number of extinct species in the sands is said to be from 15 to 20 per cent.; and if we compare this with the 18 per cent. extinct species of the Norwich Crag, the inference seems obvious that the beds are *pre-glacial*.

Prof. Geikie points out, however, that such comparisons are only conclusive when confined to the same geographical area; and when we substitute the Italian Pliocene for the English, a very different conclusion is suggested. For in the lowest beds of the former the per-centage of extinct shells is 83, and in the Upper 68. If, then, these Italian Pliocene are rightly classed, the lignites must be at any rate Post-Pliocene. But even then, it is still possible they may have been formed before the ice reached the district where they occur. A local geologist, however, the Italian Prof. Gastaldi, does not consider the Italian lignites to be interglacial. At the same time he believes them to be of the same age as the Swiss beds. But if the Swiss lignites lie *upon* glacial beds, and the Italian *below* glacial beds, and if they are of the *same* age, it *follows* that the lignites *must* be interglacial.

The argument seems to hinge on the question whether the organic remains indicate a similar age for the lignites on the two sides of

[1] Great Ice Age, p. 527.

the Alps. Mammalian remains are found in Swiss lignites, and are of distinctly recent aspect: they are,—

(1) Asiatic Elephant (*Elephas Indicus*) (*E. antiquus*?).
Urus (*Bos primigenius*).
(2) Stag (*Cervus elaphus*).
(3) Cave Bear (*Ursus spelæus*).
Rhinoceros sp. (*R. Merkii*?).

(1) It is somewhat difficult to decide how old a deposit may be which contains this living species, as it is so seldom found fossil.

Writing in 1868, Dr. Hugh Falconer states that, "There is no good evidence of the existing Indian Elephant having as yet anywhere in India or in Europe been met with in the fossil state."[1]

And according to Woodward and Sherborn (British Fossil Vertebrata) it has not been found fossil in Britain.

(2) This species is found in the ossiferous caves of Wales and Gibraltar, in the Norfolk Forest-bed, in Pleistocene, Prehistoric, and Historic deposits. This leaves a wide margin for the age of the beds in which it occurs.

(3) This occurs in the Forest-bed, in the Pleistocene, and in the caves. Again no evidence as to age.

On the whole such an assemblage might have occurred at any period from late Pliocene to Postglacial times. And yet the general aspect of such a fauna suggests a *later* period than one in which 15 or 20 per cent. of the Mollusca are extinct.

And finally, even if the lignites are interglacial as to position, this does not, as we have seen, necessarily indicate a warm interglacial climate.

In America, again, Professor Geikie finds evidence of warm interglacial conditions:

"Another interesting feature in the American glacial deposits is the occurrence of intercalated fossiliferous beds."[2]

According to Prof. Newberry the succession of changes indicated are as follows:

1st. A period of a great continental glacier or ice-sheet.

2nd. The retreat of the ice, and the appearance of a vast freshwater lake (covering a large part of Ohio), in which were deposited the Erie clays, etc.

3rd. The silting-up of the lake, and the advent of a luxuriant forest-growth.

4th. The submergence of the land and the deposition from floating ice of blocks and boulders.

And the resulting succession of beds was as follows in descending order:

1. Iceberg drift.
2. Forest bed.
3. Erie clays.
4. Glacial drift.

The "Iceberg Drift" above the Forest Bed, however, does not necessarily imply a return of Arctic conditions after a mild interval; it may simply represent a phase in the gradual retreat of the ice when its southern extent was still greater than it is to-day.

[1] Pal. Mems. vol. ii. p. 157. [2] Great Ice Age, p. 416.

It may have retreated far enough to allow of the deposition of the Erie clay in Ohio (between lat. 38° and 42°) near its extreme southern limit, the silting up of the lake, and the growth of forest upon it.

If the land then sank, it need not be supposed that the southern fringe of the retreating ice was too far off to allow it to send ice-bergs floating over the submerged land, and depositing the "Ice-berg Drift" on the "Forest-bed."

The phenomena of the American "inter-glacial beds," in fact, seem to mark the retreat—perhaps intermittent and with prolonged pauses—of the ice, rather than the occurrence of a warm climate between two periods of cold.

And this is the opinion to which Dr. Wright inclines after prolonged and careful study of the glacial deposits and actual glaciers of North America, although it is in opposition to that expressed by other American geologists. In his "Ice Age in North America," he expresses himself thus:

"A thorough study of the condition and distribution of the buried forest beds bears strongly, as I cannot but think, against the complete separation of glacial epochs in North America. In addition to the facts about to be enumerated, it is a significant circumstance that the buried vegetable deposits under consideration do not mark a warm climate, but a climate much colder than the present—such a vegetation, in fact, as would naturally flourish near the ice margin. The buried forests of Southern Ohio have a striking resemblance to those we described in Glacier Bay, Alaska. Peat and hardy coniferous trees are predominant."[1]

And again,

"Usually, as has been remarked, these buried deposits of peat and wood have been assumed to imply the existence of two distinct glacial periods. But, from what has been said above, it would appear that the facts point rather to shorter periods of advance and recession of the ice-front, analogous to those which are now in progress in the Alpine glaciers, as heretofore noted."[2]

At the same time Dr. Wright admits difficulties in the case of some of the more northern deposits:

"It must be confessed, however, that some of the facts concerning vegetal deposits still further north, especially in the valley of Lake Agassiz, are more difficult to explain upon the theory of a single glacial epoch."[3]

And finally summing up the matter he writes,

"Such are, in brief, the considerations which seem to make it proper to hesitate before recognizing the theory of two distinct glacial epochs in America as an established doctrine to be taught. Most of the facts adduced to support the theory of distinct epochs are capable of explanation on the theory of but one epoch with the natural oscillations accompanying the retreat of so vast an ice-front."[4]

The intercalated beds on the Norfolk coast are instructive. They

[1] *Ib.* p. 482. [2] *Ib.* p. 490. [3] *Ib.* p. 495. [4] *Ib.* p. 500.

are described by Mr. Clement Reid[1] as "well-laminated ripple-marked clays and marls with seams of fine false-bedded sand, deposited on the hummocky surface of the First Till," and are in turn overlaid by the Second Till. They have not yielded any fossils except shell fragments derived from the Boulder Clay, and Mr. Reid is led to the following conclusions as to their origin:

"The absence of all signs of life appears to point to a freshwater origin for these beds, and for the similar unfossiliferous laminated clays which are so common in glacial deposits in other parts of England. Modern glacial lakes show a similar barren character" (p. 88).

Finally, Mr. Reid does *not* consider that they afford evidence of an inter-glacial warm climate:

"After the deposition of the First Till, the ice appears to have retreated, perhaps only for a few miles, leaving the Boulder Clay with a curious hummocky surface, over which was deposited ripple-marked clay and marl in thin beds. This deposit seems to be glacial mud, such as would flow from beneath the ice, and be spread over the surface lately abandoned. Such an evenly-bedded loam cannot be taken as sufficient evidence of an inter-glacial warm climate, though it is traceable nearly continuously for at least four miles; for at the present day glaciers of the Alps and the ice of Greenland advance and retreat short distances without any very marked cause."[2]

Nor do the sands which come between the second Till and the Boulder clay or Stony loam afford any stronger evidence. They are described as "fine false-bedded loamy sands, always chalky and carboniferous, and of a peculiar pale tint, easily recognizable;" and they rest on the eroded surface of the Till. Like the beds between the first and second Tills they have yielded no fossils.

And this so-called Boulder-clay is a deposit of rather a curious character. In general composition according to Mr. Reid it is much like the underlying till, but it contains *bedded masses of sand* of which the bedding is often vertical. It perhaps marks an advance of the ice less pronounced than that which produced the second Till, and which permitted more freely the action of streams.

The inconclusive nature of the evidence derived from the intercalated sands and gravels is further illustrated by a study of those of South Lancashire as described by Mr. A. Strahan (Q.J.G.S. vol. 42, p. 362).

According to Mr. Strahan these sands and gravels "usually underlie Boulder-clay." Yet there is no evidence of glacial action beneath them: "Lastly, it is almost invariably under Boulder-clay that the rock has been found to be striated. Though the sands and gravels are included among the glacial deposits, the Boulder-clays alone show direct evidence of the action of ice." On the Welsh coast, on the other hand, Boulder-clay is described lying beneath marine drift:—"The occurrence of a tough blue basement clay

[1] Geology of the Country around Cromer, Mem. Geol. Surv.
[2] Ditto, p. 91.

packed with stones, most of which are scratched, underneath the undoubted marine drift of the Welsh coast, has been previously noted."

The view that these sands and gravels are interglacial rests on the assumption, that the beds thus lying above the Boulder-clay in one place are of the same age as those lying beneath it in another.

The mammalian and other remains found in the intercalated beds are taken by Professor Geikie as evidence of the mild climate he supposes to have prevailed. Yet similar remains are noted as occurring in the Till itself:

"In the mass of the Till itself fossils sometimes, but very rarely, occur. Tusks of the Mammoth, Reindeer antlers, and fragments of wood have from time to time been discovered in this position."[1]

And there are so many ways in which such remains as are found in the intercalated beds might come to be imbedded in them that a mild interglacial climate should not be assumed without very strong evidence.

It seems to be generally inferred, that the glacial conditions drove such Mammalia, and other temperate forms, out of the country, and that a mild interval, and a union of England with the continent, was required to allow of their return.

But is it not possible they may have lingered in the southern unglaciated districts, migrating northwards during the summer, and occasionally leaving their remains where glacial deposits were being laid down? And a succession of warm summers might induce them to travel to higher latitudes than usual. And it is worthy of note that these mammalian remains are found in the *lower districts*, where there would be less ice and milder conditions, and where the ice was likely to melt most completely during the summer. Prof. Geikie accounts for their absence on the higher grounds by the greater intensity of the glaciation which he thinks removed them; but the alternative explanation that they never existed there is worthy of consideration. And a hint of how mammalian remains may come to be imbedded in deposits far beyond the usual habitat of the species is afforded by Dr. Meyer, in his account of his recent exploration of the glaciers of Kilimanjaro in Eastern Equatorial Africa:

"We were about half way through this terrific bit of work," he writes, "when we came upon what was perhaps as wonderful a discovery as any we made in Kilimanjaro. It almost savours of the fabulous, but here in this stern frost-bound region, at the very summit of a mountain 20,000 feet high, we lighted on the dead body of an Antelope—one of the small species we had noticed on the pasture-lands below. How the animal came there it is impossible to say. In all probability it had made its way upward by the same path as ourselves, at a time when the ice was covered by its winter coating of snow, and overtaken in these lofty solitudes by the fury of a mountain-storm, had paid with its life the penalty of its adventurous curiosity."[2]

[1] Great Ice Age, p. 164.

[2] Across East African Glaciers, by Dr. Hans Meyer, pp. 183–4.

And Colonel Tanner, in his description of a Himalayan glacier, shows how vegetation and ice-action may overlap. The following passage occurs in a paper read before the Geographical Society (see *Nature*, April 30th, 1891, p. 622):—

"Speaking of the Himalayan glaciers, Colonel Tanner stated that the most extensive and picturesque he has ever seen are in the Sat valley, which drains the southern face of the Rakaposhi mountain in Gilgit. Three great glaciers come down into this valley, and dispute with the hardy mountaineers for the possession of the scanty area of the soil. Here may be seen forests, fields, orchards, and inhabited houses all scattered about near the ice heaps. The only passable route to the upper villages in this valley crosses the nose of the greatest of the three glaciers, and threads its way over its frozen surface. This glacier is cut up into fantastic needles of pure green ice, some of which bear on their summits immense boulders. About half a mile from its lower end or nose, Colonel Tanner found an island bearing trees and bushes, and at one place above this a very considerable tarn of deep blue-green water. The glacier had two moraines parallel to it and with each other, and both bearing pine trees."

Dr. Wright also describes the close proximity of glaciers and an abundant flora and fauna in North America at the present day:

"The mountains on each side of Muir Inlet rise immediately from the water from three thousand to five thousand feet. These we often ascended, and were thus permitted repeatedly to behold one of the most marvellous views anywhere to be found in the world. At that season the level places around our feet upon these summits were carpeted with soft green grass, interspersed with large areas of flowers in full bloom. Here were extensive, gorgeously-coloured flower-beds, where bluebells, daisies, buttercups, violets, the yellow arnica-flower, and the purple epilobium, were striving for mastery or for recognition. On the northern slopes of slight elevations great masses of snow were preserved in the very midst of these brilliant flower-gardens, and from their melting, clear little pools of water were on every hand inviting us to drink. The tracks of the mountain goat, the mountain lion, and of various smaller animals, and the songs of birds witnessed to the abundance of animal life. . . . In such a setting of grandeur and beauty we gazed upon the full face of the great glacier itself lying at our feet. Below us its diminishing outlet disappeared in the waters of the bay. Distance made the rough places plain, and lent enchantment to the view. Down from the mountains in every direction from the north came the frozen torrents;—

> Glaciers to the right of us,
> Glaciers to the left of us,
> Glaciers in front of us,
> Volleyed and thundered—

pouring into a vast amphitheatre, and then uniting their volumes, preparatory to their exit through the entrance into Muir Inlet."[1]

[1] Ditto, pp. 37–39.

The same writer further describes some of the islands in Glacier Bay—at the head of which is Muir Inlet—as covered with vegetation:—"Near the mouth of Glacier Bay is a cluster of low islands named after Commander Beardslee, of the United States Navy. There are twenty-five or thirty of these, and they are composed of loose material—evidently glacial *débris*—and are in striking contrast with most of the islands and shores in south-eastern Alaska. These, also, like all the other land to the south, are covered with evergreen forests, though the trees are of moderate size."

It is obvious that a very slight advance of the ice—such as are known to be of common occurrence—might cover this vegetation with glacial deposits and present all the phenomena of "interglacial beds."

Another indication of the possible close association of a Mammalian fauna, and the action of ice is furnished by the phenomena of the region of Hundes in India.

No glaciers descend there below 14,000, and very few below 16,000 or 17,000; and it has been shown by Mr. Lydekker that Wild Horses (*Equus hemionus*) and Yaks (*Bos grunniens*) live there at elevations of 15,000 feet. That remains of these could very easily be imbedded in glacial deposits is obvious.[1]

And that vegetation may occur on the *higher* ground, while intervening valleys are filled with ice, is indicated by Lydekker's account of the glaciers of Baltistan.

Of the Tápsa glacier he writes:

"Cypress trees extend to a height of 1000 or 1500 feet above the level of the glacier."[2]

A further illustration of the overlapping of an even temperate vegetation with the ice is given in Rendu's "Glaciers of Savoy."

He speaks of the ice advancing between banks covered with flowers, and adds, "I stopped near a field of rye which was by the side of the Glacier des Bossons. An ear, almost ripe, and swayed by the wind, each instant touched the ice, and drew back as if frightened by this strange guest come from a climate which has no power save for death."[3]

It is obvious, in fact, that while the higher part of a glaciated region may be removed from all animal or vegetable life, the lower or melting portion must in some way invade the zone of living creatures, and thus tend to mingle their remains with the tokens of ice action.

But do the facts of the case admit the supposition that any considerable portion of our fauna and flora were actually able to exist in the southern unglaciated portion of Britain during the period of intense cold?

On the hypothesis that the ice-sheet extended as far south as the latitude of London, there seems but a small area left—and that in close proximity to a great ice-sheet—for its conservation. But in

[1] See Geol. Mag. May, 1891, pp. 209–210.
[2] Records Geol. Surv. India, vol. xiv. p. 44.
[3] Translation, p. 68, Edited by Prof. George Forbes.

connexion with this point some remarks of Sir Charles Lyell in relation to existing conditions in Greenland should be borne in mind.

"The perpetual snow," he writes, "usually begins at the height of 2000 feet, below which level the land is for the most part free from snow between June and August, and supports a vegetation of several hundred species of flowering plants, which ripen their seeds before winter. There are even some places where phenogamous plants have been found at an elevation of 4500 feet, a fact which, when we reflect on the immediate vicinity of so large and lofty a region of continental ice in the same latitude, well deserves the attention of the geologist, who should also bear in mind that while the Danes are settled to the west in the 'outskirts,' there exists due east of the most southern portion of this ice-covered continent, at the distance of about 1200 miles, the home of the Laplanders with their Reindeer, Bears, Wolves, Seals, Walruses, and Cetacea. If, therefore, there are geological grounds for suspecting that Scandanavia or Scotland or Wales was ever in the same glacial condition as Greenland now is, we must not imagine that the contemporaneous fauna and flora were everywhere poor and stunted, or that they may not, especially at the distance of a few hundred miles in a *southward* direction, have been very luxuriant." [1]

Nor must we lose sight of the *possibility* that the land extended further south in glacial times than now; or was even perhaps joined to the continent. For it is still a moot point whether glacial Britain was a cluster of low, ice-covered islands, or a highly elevated glaciated region surrounded and united to continental Europe by a great plain inhabited by an abundant flora and fauna.

We must further remember that the supposition that the ice-sheet extended thus far south is founded on the hypothesis that the Till was formed *beneath* the ice-sheet, and this view of its formation is by no means certain or universally received.

Prof. Boyd Dawkins, for example, points out that the evidence from "causes now in operation" is against this view. For, as he remarks, no similar deposit is found where glaciers or ice-sheets have retreated; whereas in Davis Strait an analogous formation is being laid down by the water from the melting ice entering the sea.

If this view of the formation of the Boulder-clay be adopted, the ice-sheet may be supposed to have terminated much further to the north, and the difficulty of supposing a part of the pre-glacial fauna and flora to have found an asylum much lessened.

The peculiar flora of the south-west of Ireland seems to me to afford a hint that a portion, at least, of our plants and animals were not entirely driven out of the country. For there are difficulties in the way of the supposition that this peculiar flora—not now found further north than Spain and Portugal—migrated there *after* the glacial epoch; and Prof. Forbes, in his essay on the fauna and flora of the British Isles, inclines to the view that the migration took place *before*.

If this is true, these plants must have survived the Glacial epoch; and if these, why not many others of our plants and animals?

[1] Antiquity of Man, p. 278.

A similar hint is offered by the fact that the glacial drift of the west of England, and of parts of Ireland, contains mollusca of a more southern aspect than that of the east side of the former. For it allows us to suppose a milder climate existing on the west all through the period of cold, and thus affording a retreat for forms which might otherwise have perished.

Thus, although the question of the probability of mammalian and other remains in the glacial drift of Britain without the intervention of warm intervals, cannot be definitely settled until the preliminary one of the extent of the land of the Glacial period is disposed of, enough has been brought forward to show how easily it might happen under certain conditions.

Finally, it may be affirmed that the evidence that the intercalated sands and gravels were formed during a mild interglacial period is in *no single case* conclusive; that while they are *not* the sort of deposits to be, *a priori*, expected as the result of a mild interval, they *are* just such as would naturally result from the action of sub-glacial streams, the oscillations in the extent of the ice causing the overlapping of glacial and aqueous deposits, and the work of the ice itself; and that a gradually, but intermittently, advancing ice-sheet, or glacier, could not avoid overwhelming and burying in its own debris masses of vegetation, while the latter, closely following the retreating ice, and growing on its accumulations, could not fail now and again to be buried beneath the deposits of some temporary advance of the same.

And since, looking to the present, the work actually done beneath an ice-sheet or glacier—especially in those parts remote from its lower margin—is still shrouded in mystery, it seems rash to assign every bed which does not conform to our usual idea of the work of the ice to an interglacial epoch.

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## V.—Recent Geological Investigations in the Salt Range.

By A. B. Wynne, F.G.S.

THE Geological Survey of India Records, vol. xxiv. part 1, 1890, only came to hand to-day, enabling me to see Mr. Middlemiss's late paper on the Salt Range.

It appears to be one of the many charms and mysteries of Salt Range geology that it affords fresh discoveries to each successive explorer; hence, possibly, something yet remains to reward the next pilgrim who may have the chance to criticize Mr. Middlemiss's conclusions,—let us hope instructively.

The paper at present referred to possesses a great deal of interest, and has much importance with regard to structural geology. I trust it may receive worthy notice under light more modern than that in which my Salt Range work was carried out more than twenty years ago, without the advantage or disadvantage of a tendency to form foregone opinions about the views of others before I reached the ground. Perhaps I may also remind readers that when I was thus engaged, the doctrines of inversion, earth-thrusts of several

miles, and shearing, so largely affecting Mr. Middlemiss's views, and which arm his criticisms, were in their early infancy or still unborn, and had not been developed by the exhaustive researches in complicated districts of the Scottish geologists, whilst complex superficial displacements from landslip abounded in degree and magnitude sufficient to render conclusions as to inversions, etc., such as the paper advances, very doubtful.

One conclusion (not the author's alone), namely, that the Boulder beds form a single continuous horizon, seems incontrovertible upon the accepted evidence advanced for unconformity. This relation is easier to understand when it is assumed that the Salt Marl is an accidental associate, and not integral as an original basal part of the series. Regarded as of the latter nature, in intimate connexion with the lowest succeeding members, whether boulder conglomerates or sandstone, it was of course impossible to hold such boulder rocks to be contemporaneous with others, at a higher stratigraphical level, in an apparently perfectly conformable sequence. The interpretation depended upon the existence of either conformity or discordance within beds lying in a general way more or less horizontally, and the question formed one of those problems more likely to be solved by the application of broad considerations than of local details.

The paper itself suggests an illustration of this where reference is made to derived pebbles as proofs of discordance; for it is an uncontested fact that sandstone beds *in the Eocene group* trans-Indus enclose rounded pebbles of fossiliferous Nummulitic limestone, and are overlaid by conformable beds of similarly fossiliferous Eocene limestone with little or no disturbance (Mem. G. S. I. vol. xi. p. 35, *et. s.*). In other cases formations containing rolled fragments of their own rocks have also been recorded. The inference from these cases is quite as strongly in favour of conformity as of discordance: in fact, as strict evidence of the latter, the occurrence of these pebbles has little or no weight. If this be true of trans-Indus Nummulitic pebbles, why should it be otherwise as to dolomite pebbles from the Salt Marl in an overlying conglomerate? or as to Eocene limestone pebbles in the next Tertiary layers above? In each case the separation as to time is reduced, and the likelihood of a break diminished, leaving to wider general considerations rather than to dogmatic rules the position of the safest guides. At the same time the contention of Mr. Middlemiss may be correct, but the case affords an instance in which each observer is at liberty to form, or even to alter, his own conclusions according to his lights.

The most important part of the paper is the author's suggestion that the sub-Cambrian Salt Marl has no ordinary stratigraphic relations with the rest of the series, but is of plutonic, igneous or deep-seated origin, introduced in Tertiary times, accompanied by lateral and vertical disturbance, thrusting, and shearing. The idea of an igneous or deep-seated origin for rock-salt formations is not new; it was considered and discussed so far as possible before my Salt Range Memoir was written, but there did not then seem

sufficient evidence to found a case adverse to the generally received theory of production of saline deposits. I gather that, notwithstanding what is now advanced, the case is still incomplete, yet I trust Mr. Middlemiss will follow up the subject to conclusions that cannot be called hypothetical, and may effectively reconcile several obscurities on both sides of the Indus.

When I was at the Salt Range, the facts of internal lateral thrust displacements not having been demonstrated, it was plain the series must have been laid down upon something, and the marl occupied the place of the visible floor to the rest. Supposing the part above to have been unconformably deposited, what conditions would have preserved a soft saline marly mass to have received later accumulations? But if it was found immediately succeeded by earthy layers passing up into sandstones, the main conditions for tranquil sequence would seem to have been present as I saw the sections. I have not seen the brecciated junctions of the Purple sandstone with the underlying marl as described in the paper, nor do I quite grasp how such a condition—not merely superficial, but the result of deep friction—might be established between substances like soft 'scum' and hard sandstone. This, of course, is said with reserve, and subject to correction by students of earth-movements, thrusting, and so forth, which I have not had the advantage of working out in natural exposures.

While greatly interested in Mr. Middlemiss's frank, able, and lucid contribution to the literature of the Salt Range, I am yet fain to hope that—aside from subsequent revelations in structural geology—other readers of my memoir will find most of its conclusions reasonable at the time it was written. Our knowledge is happily progressive, and considering the extent of the region itself, with the circumstances governing its exploration, I can scarcely feel vain regret that something did, or may still, remain to be discovered. On the contrary, few will learn with greater satisfaction of solid additions or improvements to what has been already ascertained, notwithstanding that the results, such as they were, which attended my labours for rather more than two working seasons, cost me a good deal of thought and exertion, with serious loss of health, and consequently of my employment—considerations, however, already amply recognized as having nothing whatever to do with the geology of the Salt Range or other regions. Nevertheless, the retrospective pleasure of appreciating the observations of later investigators made upon the spot, must still remain possible to an old field-geologist like myself.

Kingstown, 23*rd July*, 1891.

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## VI.—Report on some Rock-Specimens from the Kimberley Diamond-Mines.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., and Miss C. A. Raisin, B.Sc.

[From a collection of stones obtained from the refuse-heaps of the Kimberley Mines by Mr. Louis Atkinson, a selection was made

by Prof. T. Rupert Jones and, by kind permission of Prof. Bonney, was submitted to him for examination, in packets marked I.—VIII. and X. Specimen No. IX. was sent many years ago, as a trap-rock with garnets from the Vaal River, by Mr. Robert Crofts Jones.—T. R. J.]

For the most part the specimens were too small to permit of slices being made; the results therefore were in such cases obtained by examining the powder got by crushing the fragments.

I. *a*. The green mineral is Enstatite, and is associated with a colourless transparent mineral, appearing cracked and fractured, which seems to be probably Topaz.

*β*. A clear bright-green crystal of Enstatite.

*γ*. The green mineral is a Pyroxene, and is intercrystallized with red Garnets.

*δ*. A slide was prepared of this specimen, which showed that it consisted of Garnets enclosed in a green Pyroxene, probably Omphacite, with small rifts or tubuli traversing the crystal transverse to the prism-zone. A colourless transparent mineral is associated with the Pyroxene; it has straight, or nearly straight, extinction, and might be Zoisite or possibly Kyanite.

II. *a*. A transparent, pale, resin-coloured specimen of Topaz.

*β*. A bright green Pyroxene, with a yellowish or greenish-grey mineral, which has one good cleavage and straight extinction, and may be Zoisite. Very dull purplish Garnets are included, and flakes of brown Mica.

*γ*. A Pyroxene of rather foliated habit, having a clear, deep, rich green colour and a sub-metallic lustre, apparently like the Omphacite described by von Drasche. To this is attached a white fibrous mineral evidently a carbonate, probably Calcite.

*δ*. A pale sea-green mineral with silky or pearly lustre, which shows well-marked cleavages, breaks into rhomboidal forms, and appears to be a variety of Diallage.

III. Many specimens of Iron-pyrites; also others of a rock composed of Pyroxene, Garnet, and (?) Zoisite.

IV. *a*. Matrix seems to consist of minutely granular Serpentine and Olivine with some brown Mica—a ground-mass apparently similar to that in the slide cut from specimen VI. Green crystals of Augite are enclosed.

*β*. Garnets enclosed in a clear greenish mineral, very pale in tint when seen in thin flakes under the microscope, and somewhat foliated; it is probably a pyroxene of the nature of Omphacite.

*γ*. Three specimens of *Garnet-pyroxene-mica-rock*, as described, II. *β*.

*δ*. Three specimens of *Garnet-pyroxene-*(?)*zoisite-rock*, as previously described, III.

V. Specimens of Ilmenite (called "carbon" by the miners).

VI. A slide prepared from this rock shows a ground-mass, the constituents of which are difficult to distinguish; it appears to be an irregular mixture of brown Mica, brownish-green Serpentine, and a dirty-looking mineral, which is seen with polarized light as an aggregate of fine granules, and in parts seems to be associated with

the serpentine in a sub-ophitic way. Within the ground-mass are well-formed crystals of green Augite, also red Garnet and brown Mica. Some Olivine is in good preservation, and Serpentine occurs, dark- to light-green, the result of the alteration of a ferro-magnesian silicate, most probably an Olivine rather rich in iron. The rock thus would seem to be a *Granatiferous Picrite.*

VII. These irregularly cylindrical bodies consist apparently of small fragments of the minerals of the rocks, Garnet, Pyroxene, etc., and also of well-rounded Quartz grains, all the constituents being cemented together, apparently by Calcite. The structures may very possibly be concretionary and have formed within a sandy rock.

VIII. From examination of the powder obtained by crushing a fragment, this specimen appears to be Pyroxenic,—a pale-greenish minutely crystalline Augite.

IX. This rock consists of red Garnets, with rather perfect crystal faces, imbedded in a brown ground-mass. A slide has been prepared which shows that the matrix consists of an ill-defined crystalline mass, including either incipient or partially-decomposed forms of a mineral which has an appearance suggesting crystal outlines of a Felspar-like character. Some Quartz may also be present. A brown Mica occurs, rather iron-stained, and somewhat confusedly crystallized. There are also crystals, which are short stout prisms, rather rounded, terminating in basal and dome planes, transparent and colourless, highly refractive, and with straight extinction; these may possibly be Topaz. The somewhat decomposed and iron-stained condition of the rock makes it difficult to speak with precision, but on the whole the probability is that it is a somewhat altered fine-grained *Granatiferous Mica-Diorite.*

X. Quartz pebbles.

### *Note by Prof. T. Rupert Jones, F.R.S.*

The following specimens were previously supplied by Mr. L. Atkinson, and returned to Kimberley labelled for the use of the miners and others.

1. Slag of "Blue Ground" (local matrix of the diamond) artificially burnt.

2. Tufaceous concretions, roughly cylindrical and branched, formed locally near the surface, from the decomposition of the felspar of igneous rocks yielding carbonate of lime, and the calciferous water percolating sandy strata.

3. Pebbles and fragments of chalcedony from the agates of amygdaloids, either local or drifted from the upper country. 4. Quartz crystal, probably from an agate. 5. Calcite, probably from the local tufa or from an agate. 6–10. Iron-pyrites in irregular, knobbly, concretionary forms; Hematite; Ilmenite; Garnet; Epidote; probably from the "Blue Ground."

11. Shale veined with calcic carbonate. From the "Kimberley Shale" of the "Lower Karoo" formation, traversed by the diamond-stuff. 12. Porcellanite; possibly burnt shale. 13. Silicified wood; coniferous, from the "Upper Karoo" formation. 14. Soft ferru-

ginous grit-stone; probably from the Karoo Beds. 15. Sandstone; from the Karoo Beds. Nos. 13 to 15 have been drifted from the Stormberg and neighbourhood higher up the country. 16. Pebble of brown quartzite; possibly from the Karoo Beds.

17. Mundic in slate. 18. Siliceous schist, or brown banded lydite. 19. Jasper. 20. Vein-quartz. Nos. 17—20 have been derived from the old rocks; probably having been brought up from below, but possibly drifted on the surface.

The mineral contents of the diamond-matrix or "Blue Ground" of Kimberley (De Beer's, etc.) were described by the late Professor H. Carvill Lewis in the Geol. Mag. 1887, pp. 22–24.

The diamond-yielding gravel of the Vaal River, partly drifted from the igneous and the old rocks of the higher country on the East, and partly derived from diamantiferous necks and patches, has much analogy to that of the refuse-heaps or washed stuff of the diamond-mines. The constituents of the Vaal gravel, and of that of Dutoit's Pan, are enumerated in the Geol. Mag. 1871, pp. 55, 56; and Quart. Journ. Geol. Soc. vol. xxviii. 1871, pp. 17–21.

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## VII.—On a Glacial Mound in Glen Fruin, Dumbartonshire.

By Dugald Bell,
Geological Society of Glasgow.

GLEN FRUIN[1] is a quiet secluded glen, about six miles in length, extending in a north-westerly direction between Lochlomond and the Gareloch, and opening off the neck of land which divides those lochs at between 200 and 300 feet above the sea. To the south-east, it slopes towards Lochlomond, of which the Fruin water is one of the principal affluents. On the west it is divided from the Gareloch by a range of hills 1000 or 1200 feet in height, which at its upper extremity subside into a col or pass of 600 or 700 feet. This upper part of the glen is composed of the mica and clay slates common to the Western Highlands. The lower part is formed of beds of the Calciferous Sandstone series, which have here been faulted down against the older formations.

The upper part of the glen bears every indication of having been at one time occupied by a lake.

A huge boulder of mica-schist, resting on the sandstone, occurs near the foot of the glen, and there are many smaller ones in the same neighbourhood. The respected Convener of the Edinburgh Boulder Committee, the late Dr. Milne-Home, thought this large boulder had been brought by an iceberg (which was his favourite means of transport) either coming down Lochlomond and drifting aside into Glen Fruin, or more probably finding its way over the head of the glen during a period of "great submergence."

The iceberg hypothesis seems to be attended with insuperable difficulties, when we consider (1) where such large icebergs could be formed in the event of so great a submergence as the theory

[1] The "Glen of Sorrow," scene of a sanguinary conflict between the Colquhouns and Macgregors in 1603. (See Introduction to "Rob Roy.")

requires; and (2) by what possible main currents of the ocean, which alone could move them, they could be brought to these localities and positions. For these and other reasons, it seems more probable that such boulders owe their transport to a great sheet of land-ice which once filled the glen from side to side, proceeding from the Argyleshire mountains on the north-west, and overflowing the neck or col at the bend of the glen as also that at the head of the Gareloch, between it and Lochlong.[1]

This view is strongly corroborated by the phenomenon we have now to describe, viz. a remarkable mound of detritus which occurs about half a mile farther up the glen than the large boulder referred to, and extends for a considerable distance in a winding line across the hill-side in a direction from S.W. to N.E., i.e. *transverse* to the glen. It is most conspicuous on the eastern side of the glen, where it runs from 300 to about 500 feet above the sea, "tailing out" on the hill-side towards Lochlomond at a still greater elevation; but it can be traced on the western side also, in the same general direction, though there the ground is lower, and not so favourable for its preservation. It is composed of typical moraine matter—large and small stones, sand and gravel, confusedly mixed together; many of the stones being distinctly striated. Some are sandstones from the immediate neighbourhood; others, schists and quartzes, from greater distances.

The mound varies from 10 to 20 or 25 feet in height, and from 20 to 30 feet in breadth. In some parts it resembles a row of hummocks of varying height; in others it rises from the surrounding moor, distinct and continuous as a railway embankment. A number of boulders, some of considerable size, are perched on its sides or summit, and strewn along its base.

There can be little doubt this is a "terminal moraine" of the great ice-sheet which once occupied the glen; and we may add it is one of the most notable and characteristic which we have seen in the West of Scotland.

A number of detached mounds of considerable size occur at lower levels, beyond the opening of the glen towards Lochlomond, and may be relics of still older moraines.

Meantime the one we have described suggests the following inferences:

1. There has been no submergence to this point *since* the mound was deposited. Its rough, undressed, unstratified condition—its very existence as a distinct mound—proves this. Had there been a submergence of as much as 500 feet since it was deposited, such a loose earthwork would soon have been demolished and effaced by the currents sweeping across this low neck of land between Lochlomond and the Clyde.

2. For the same reason, there could be no submergence to that extent *while* the mound was being deposited. Some geologists hold that the ice-sheet reached the sea as the land rose (assuming a submergence) and laid down such mounds along the sea-margin. In

[1] As noticed many years ago by C. Maclaren; Edin. New Phil. Journ. vol. xi.

that case they would surely have borne distinct marks of assortment and stratification, especially in localities where strong currents must have been in operation.

3. Nor, finally, is there any proof of a "great submergence" *prior* to these latest works of the ice. This is where the advocates of such a submergence join issue. They maintain that there was a first or general glaciation, then a deep submergence, then a partial or local glaciation, by which all distinct traces of the submergence were removed. But a little reflection will show (*a*) that it is very improbable any subsequent local glaciation could remove all traces of the sea's presence at high levels, supposing it had been there. The sea marks a *horizontal* line and goes into every nook and cranny of the land along the line; whereas the glacier marks a *descending* line, and keeps to one main channel, not branching off in every direction as the waters do. The *area* of the glacier, therefore, could not coincide with that of the submergence so as to remove all traces of the latter.[1] Then (*b*) if such traces *had* been entirely removed

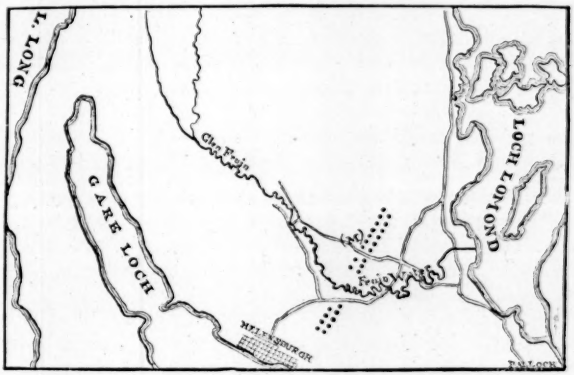


FIG. 1.—Sketch Map showing position of Mound (M.)

FIG. 2.—General Aspect of the Mound.

from every glen like this Glen Fruin, they should at least be discernible in the heaps of débris which the ice has left near the mouths of such glens. All over the country there are innumerable glacial mounds and heaps—the "sweepings" of glens which, in the case of the alleged submergence, must have been sheltered inlets of the sea, favourable to almost every form of marine life. These heaps, as well as the Boulder-clay of the country generally, should abound in fragments of marine fossils, if there had been such a

[1] See Trans. Geol. Soc. of Glasgow, vol. ix. p. 109.

submergence, instead of being, as they are on the whole, quite destitute of organic remains.

This argument is not founded on a supposition, but on a fact. Wherever the ice can be shown (by the striæ on the rocks, the stones in the "drift," etc.) to have passed over what is still a sea-bed, or what there is no doubt was formerly such, during a very moderate submergence, there also numerous fragments of sea-shells are found in the drift or Boulder-clay; as in the instances of Caithness, Arran, Drymen, South Ayrshire, Holderness, Cromer, Lancashire, etc.

The advocates of the "great submergence" have therefore these two facts to account for: (1) the absence of all proofs of such submergence *in situ* at the high levels to which it is supposed the sea attained; and (2) the absence of all evidence of it in the débris *derived from* these high levels.

## REVIEWS.

I.—An Introduction to the Study of Mammals Living and Extinct. By William Henry Flower, C.B., F.R.S., D.C.L., etc., etc., and Richard Lydekker, B.A., F.G.S., etc., etc. 8vo. pp. xvi. and 763, Illustrated with 357 Woodcuts. (London, Adam and Charles Black, 1891.)

THE authors of this important Manual have rendered a most valuable service to Biological Science by furnishing us with a book, long wanted, but heretofore not to be met with in any country or language, and one which will be eagerly sought after by zoologists and palæontologists engaged in the study of the higher Vertebrates all over the world.

The few manuals approaching somewhat to this in size, in other countries, are of too popular a character to be compared with the present work. We have some bulky recent works, and smaller manuals too, on systematic zoology, on palæontology, on comparative anatomy, and on the habits of mammals. In the present volume these different details are so happily amalgamated together that we are enabled to gain a good general knowledge of our subject, which a laborious journey through many volumes by various authors would have failed to procure for us.

Originally initiated as a series of articles running through the twenty-four volumes of the ninth edition of the "Encyclopædia Britannica," from 1875 to 1888, by one of the authors (Prof. Flower), the present work has the additional advantage not only of bringing all this information on the Mammalia together, but by the coöperation of Mr. Lydekker, as joint author with Prof. Flower, much new matter relative to fossil forms has been added, and the whole brought up to date, both as to the living and extinct forms.

After a brief introduction of six pages, chapter ii. (pp. 7 to 81) is devoted to the general anatomical characters of the Mammalia; these are written in terse yet clear language, and by the aid of some

twenty-four figures in the text are brought within the comprehension of the youngest student of comparative anatomy.

Chapters iii. and iv. (pp. 82 to 116) are devoted to the Origin and Classification, and to the geographical and geological distribution of the class, and will be read with deep interest by all who seek to trace the beginnings of Mammalian life on our earth.

So long ago as 1879 Prof. Huxley came to the conclusion, that in looking among the Vertebrates for the progenitors of the Mammalia we must pass over all known forms of Birds and Reptiles and go straight down to the Amphibia, "they are the only air-breathing Vertebrates which, like Mammals, have a dicondylian skull. It is only in them that the articular element of the mandibular arch remains cartilaginous, while the quadrate ossification is small, and the squamosal extends down over it to the osseous elements of the mandible, thus affording an easy transition to the mammalian condition of those parts. The pectoral girdle of the Monotremes is as much amphibian as it is sauropsidian; the carpus and the tarsus of all Sauropsida, except the Chelonia, are modified away from the Urodele type, while those of the Mammal are directly reducible to it." In 1885 Prof. Cope called attention to the remarkable resemblance to the Monotremes presented by the skeleton of that group of early Secondary reptiles which he then designated the *Theromorpha*, but which may be included in the *Anomodontia* of Sir Richard Owen, and came to the conclusion that in that group we have the true ancestors of the Mammalia.

"Since that date observations made on the structure of the South African Anomodontia have shown such an intimate connexion between this group and the Labyrinthodont Amphibians, that there can be no hesitation in regarding the one as the direct descendant of the other; and we may probably regard the Mammalia as having originated from the same ancestral stock at the time the Amphibian type was passing into the Reptilian. From this point of view, some of the mammalian features found in the more specialized Anomodonts may probably be regarded as having been acquired during a parallel line of development."

In dealing with existing forms of Mammals we find that they have become so broken up into distinct groups by the extinction of intermediate forms, that a systematic classification is perfectly practicable.

When, however, we pass to the extinct world, all is changed. In many cases the boundaries of our groups become enlarged until they touch those of others. New forms are discovered which cannot be placed within any of the existing divisions, and they are no longer sufficient for the purpose, and some other method will have to be invented to show the complex relationships existing between different animal forms when viewed as a whole.

We quite agree with the authors that a linear classification cannot be made to express the many inter-relationships existing between the different families and orders; indeed, as regards many of the fossil forms, it is almost impossible to decide where to place them in relation to living families.

On pp. 107–115 is given a summary of what is known of the Mesozoic Mammals, and on pp. 115–116, a few remarks on Tertiary Mammals; but these are dealt with in greater detail in the subsequent chapters under the heads of the groups to which they are severally allied. "The comparatively scanty evidence of mammalian life hitherto yielded by the Cretaceous (formation), coupled with the number and variety of forms approximating to the existing groups found even in the lowest Tertiary, indicates a great imperfection of the geological record. At present, indeed, we have no decisive evidence of the existence of any members of the Eutherian subclass previously to the Tertiary; but it can hardly be doubted that in some part of the world they had made their appearance before that epoch. The Eutherian mammals of the lowest Eocene, both in Europe and the United States, are of an extremely generalized type; and although many of them approximate to existing groups, they show such a combination of characters, now restricted to individual groups, as to indicate that several of the various orders into which the subclass is now divided were at the period very intimately connected. A marked feature of these early Eutherians is the prevalency of trituberculism in the dentition, not less noteworthy being the frequent occurrence of pentadactylism in the feet, while many of the individual bones were devoid of the grooves and ridges found in those of later types. By the time that we reach the upper division of the Eocene period, such as the horizon of the well-known gypsum of the Paris basin, nearly all the chief groups of mammals had become clearly differentiated from one another, although their representatives were usually more generalized than their existing allies. From this date to the later geological periods there is a gradual approximation to the type of mammalian life existing at the present day."

Turning to the table (pp. 88-92), we find the class Mammalia subdivided into sub-classes, orders and sub-orders, and lastly into families. One hundred and thirty-one families are recorded, of which eighty-six are living and forty-six are extinct. Many of the so-called families of extinct forms are represented by a single genus founded on a fragmentary individual remain, so that, although of extreme interest, they can hardly claim equal taxonomic importance with known families represented by many genera all composed of complete individuals.

We notice a trivial slip (pp. 88–89), Tritylodontidæ being given twice over in the *Prototheria* and in the *Metatheria*. The reference to it under Multituberculata is doubtless correct, and the second (under Marsupialia) may be cancelled.

Owing to the diligence of recent explorers the extinct families known are now fully half as numerous as the living, nevertheless of many of these our information is of the scantiest; nor do they help us to trace the derivation of, or the inter-relationship which we know must have existed in the past between many of the great groups which stand out to-day in strongly-marked distinctiveness from the rest of the class. What, for instance, do we know of the

derivation of the Proboscidea? the Sirenia? the Cetacea? or of the Edentata? These are some of the most difficult questions which have to be answered by the modern comparative anatomist and biologist.

Under geographical distribution the authors have adopted the Zoological regions proposed by Mr. Sclater in 1867, but although there are a few instances recorded of change of distribution due to geological causes in late Tertiary times, we may take it that in this part the fossil evidence is omitted. Thus under the Nearctic region, it is stated, "there are, however, no Perissodactyla," whereas *Rhinoceros megalodus* has been described by Cope, as well as numerous other Tertiary forms by Leidy and by Marsh.

We should very much like to see an attempt made to show the geographical distribution of the Mammalia in past times, as well as at the present day. For instance, Dr. Sclater's Palæarctic and Nearctic regions were certainly one, in late Pleistocene times, as the evidence of the Mammalia clearly shows. Thus we have *Rangifer tarandus*, *Alces machlis*, *Cervus elaphus*, and its varieties, *Ovibos moschatus*, *Bison priscus*, with the Lemming, Marmot, tailless Hare, Beaver, Fox, Wolf, Otter, White Bear and Brown Bear, the Mammoth and the Horse spread over all these Northern regions alike in the old and the new world, so that these modern geographical regions only represent the torn-up portions of far wider areas formerly connected. The same holds good of the Ethiopian and Oriental (or Indian) regions, the faunæ of which even now show such strong marks of affinity the one with the other.

Professor Flower is one of those who has advocated more strongly than any other Zoologist the importance of incorporating fossil and recent forms together; but there are not wanting signs in this volume of the difficulties which the authors have felt in attempting this course. In each family the extinct species are carefully kept apart from their recent congeners, a plan which certainly bespeaks the doubts which the authors must have often felt, owing to the imperfect nature of the fossil evidence, of incorporating them in the same series.

For a Second Edition, which will certainly not be long delayed, we venture to offer the following corrections. Among the Rodentia, to the family *Lagomyidæ*, are given $\frac{1}{1}$ or $\frac{2}{2}$ premolars (p. 491), whilst, according to Forsyth-Major, the number of premolars in this family is the same as in the *Leporidæ*, viz. $\frac{3}{2}$, this being the number of the deciduous molars, as observed in *Myolagus Meyeri*, and *M. sardus*; moreover the statement, "molars rootless," does not apply to all the members of the family, as in *Lagodus* (*Titanomys*), which for this, and other reasons, deserves to rank as a genus distinct from *Lagomys*, as well as *Myolagus*, the premolars and molars are both rooted.

In the small space at our disposal it is impossible to give more than a bare idea of the volume before us. Of its usefulness there can be no question, and we may speedily expect to see French and German editions appearing on the Continent.

We heartily congratulate the authors upon the successful issue

of their labours; they have produced a book which will greatly advance our knowledge of the higher Vertebrata, and must prove most helpful to the student of Mammalogy; nor can any Library of reference be complete without this most excellent *vade mecum*.

## II.—Armoured Palæozoic Sharks.

1. Ueber Flossenstacheln oder Ichthyodorulithen im Allgemeinen. By Dr. Otto Jaekel. Sitzungsb. Ges. naturf. Freunde, Berlin, 1890, pp. 119–131.
2. Ueber *Menaspis*, nebst allgemeinen Bemerkungen ueber die systematische Stellung der Elasmobranchii. By Dr. Otto Jaekel. *Ibid.* 1891, pp. 115–131, with Plate.
3. *Oracanthus bochumensis*, n.sp., ein Trachyacanthide des deutschen Kohlengebirges. By Dr. Otto Jaekel. Zeitschr. deutsch. geol. Ges. 1890, pp. 753–755, Pl. xxxvii.

LAST month we had the pleasure of recording important progress in our knowledge of some Palæozoic Elasmobranch skeletons, due especially to the researches of Dr. Anton Fritsch among the Pleuracanth fishes of the Bohemian Permian formation. On the present occasion we are able to chronicle another interesting advance in the study of allied forms, resulting from the renewed examination of a fossil from the German Kupferschiefer described many years ago by Giebel. It has long been known that certain representatives either of the Elasmobranchii or of the Holocephali, in Palæozoic times, possessed a remarkably developed dermal armour. Hitherto, however, the portions of this armour have almost invariably been found isolated, only few discoveries suggesting that they were fixed upon the head and anterior part of the trunk of the fishes to which they originally pertained. Quite recently Dr. Otto Jaekel has made an interesting contribution to the subject by further extricating from the matrix the supposed Elasmobranch fossil described and figured by Giebel without name in the Zeitschr. gesammt. Naturw. Halle, 1856, p. 367, pls. iii. iv.; and this is identified with a problematical fish very inadequately described by Ewald in the Monatsber. k. preuss. Akad. Wiss. 1848, p. 33, under the name of *Menaspis armata*.

The fossil in question is clearly and concisely described in the second memoir quoted at the head of this notice, and Dr. Jaekel is to be congratulated upon the success with which he has removed the obscuring film of matrix which caused the vagueness in Giebel's original figure. The specimen is but small—perhaps not more than 0·15 in length—and is interpreted as displaying the dorsal aspect to the hinder border of the pelvic fins. The head and anterior part of the trunk seem to have been comparatively broad and depressed; and the pectoral fins were evidently larger than the pelvic pair. There are three lateral pairs of much elongated dermal spines, with recurved tips, fixed upon the head; and a single pair of *Oracanthus*-shaped spines also occurs postero-laterally. Between the pectoral fins there is placed another pair of smaller broad triangular spines; and in the skin of the back there are symmetrically disposed longi-

tudinal series of spinous tubercles. Of the cartilages of the head and trunk nothing is visible; and in the paired fins there are only feeble traces of nearly parallel rays. No median fins can be seen; and the dentition is doubtfully inferred from fragments to have consisted of Cochliodont plates.

Dr. Jaekel was led to the investigation of *Menaspis* by his studies of Ichthyodorulites, detailed in the first and third of the memoirs quoted above. The result is most gratifying to those who recognize in this fossil, as now elucidated, the dawn of our knowledge of the Palæozoic armoured Sharks. At the same time, however, it is much to be regretted that before launching into broad speculations, the author did not further take advantage of the kind offices of Prof. K. von Fritsch, and borrow for study another of Giebel's Kupferschiefer fishes—*Dichelodus acutus*. If this be correctly interpreted in the original memoir (Zeitschr. gesammt. Naturw. Halle, 1857, p. 121, pl. iv.), it affects very materially some of Dr. Jaekel's generalizations concerning "Trachyacanthidæ"; and we venture to think that an examination of it would have considerably modified many matters which we regard as baseless imagination.

Whether, indeed, from an imperfect acquaintance with English, or from defective memory, or hasty work, Dr. Jaekel's theoretical remarks are full of misconceptions, which it may be of advantage in some respects to point out. In the first place, he arranges dorsal fin-spines in three divisions—the "Cestraciont," the "Acrodont," and the "Chimæroid"—according to the form of their transverse section. We would remark that *Nemacanthus* (termed "Cestraciont") and *Ctenacanthus* (termed "Acrodont") have in fact the transverse section and lateral denticles described by Dr. Jaekel as exclusively "Chimæroid"; whereas the dorsal fin-spines of the Myriacanthidæ, which are certainly Chimæroid, present differences again. In the first memoir, too, a whole page is devoted to a fundamental misconception of *Gyracanthus*; but this is cancelled (as the result of an interview with Dr. Traquair) by a footnote in the second memoir. Finally, Dr. Jaekel places all the paired Ichthyodorulites, *e.g.*, *Oracanthus*, *Erismacanthus*, *Physonemus*, *Gampsacanthus*, etc., in a new "group" termed "Trachyacanthidæ" and in the original memoir this is regarded as including both the Cochliodontidæ and the Chimæroid genera, *Myriacanthus* ("*Prognathodus*") and *Chimæropsis*.

The latest researches on the Myriacanthidæ, however, of which Dr. Jaekel overlooked the preliminary results in his first contribution, have caused a considerable modification of the "group Trachyacanthidæ" in his second memoir. *Menaspis* is still retained as a member of the new group, and made, in fact, its type; but the Myriacanthidæ are now declared to be "entirely different." So far all will doubtless be in accord with Dr. Jaekel; but when he raises this group to rank as a distinct division equivalent to—and intermediate between—the "Selachier" and "Chimaeriden," few will be satisfied with the available evidence.

Here, again, several fundamental statements require correction

before it is possible to proceed. When the author remarks that unsymmetrical spines never occur in the Selachii, we would inquire in what essential characters the cephalic spines of *Hybodus*, *Acrodus*, and *Asteracanthus* differ from *Erismacanthus*, *Gampsacanthus*, and the slender paired spines of *Menaspis*. Furthermore, the spine named *Myriacanthus granulatus* has never been regarded as a head-spine ("Kopfstachel"), as Dr. Jaekel states: and it is another error to assert that the type-species of the so-called *Prognathodus* has been in part claimed as pertaining to the same fish as *Myriacanthus granulatus*. To suppose that the typical Cochliodont dentition is of an essentially different character ("wesentlich anderes Gebiss") from that of all true Selachii, displays a very superficial acquaintance with existing knowledge of the subject; and when the author suggests that this dentition may have been firmly anchylosed with the supporting cartilages of the jaw ("mit den Kieferknorpeln fest verwuchsen"), we become alarmed by his apparent disbelief in some of the accepted fundamental principles of vertebrate anatomy. A mere reference to literature will suffice to correct the extraordinary mis-statement contained in the expression, "*Placoidei*, Ag. = *Elasmobranchii*, Bonap. = *Chondropterygii*, Cuv. emend. Günth."; and the idea that the calcification of the Elasmobranch endoskeleton always consists merely in a superficial "incrustation," will soon be removed when the author proceeds further in his studies especially of the Palæozoic genera.

Legitimate inference from an array of facts is always a welcome incitement towards new research; but when so many premises are false, theoretical disquisitions are a burden to literature. As long ago recognized by Owen, when he founded the family of Cochliodontidæ, the peculiar dentition of this group of Sharks results only from the fusion of one or more transverse series of teeth into continuous plates, which proceed to grow at the inner border in normal fashion, and curve downwards outside instead of breaking away. Every stage in this process of specialization is known, from the slightly modified *Pleuroplax* to the extremely specialized *Deltoptychius*; and the only remains of the trunk of these fishes hitherto discovered (*Pleuroplax* and *Dichelodus*) conform to the Cestraciont type—not to that of *Menaspis*. As Egerton himself observed in the original memoir, the teeth of the Myriacanthidæ bear much superficial resemblance to the dental plates of the Cochliodonts; and it is thus easy to conceive how they may have been developed at first in a similar manner from a dental armature such as was possessed by the earlier Elasmobranchs. But the teeth even of the Myriacanthidæ are already typically Chimæroid in structure and mode of growth; and to infer from the possession by these fishes of triangular dermal plates, that the Palæozoic Cochliodonts must be somehow related and armed with the ichthyodorulites named *Oracanthus*, etc., seems to us an entirely unscientific procedure. We still remain of opinion that the Cochliodonts are a specialized offshoot of the Cestracionts, and that the Menaspidæ (as the family typified by *Menaspis* ought to be termed) represent some unknown

group that yet requires elucidation. Dr. Jaekel has done good service in dispelling a remarkable illusion[1] and in adding some important facts to our knowledge of the armoured Sharks of Palæozoic times; but we will conclude with the hope that in future the author's contributions of this kind may bear signs of maturer study and be less overburdened with reckless speculation.

A. S. W.

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III.—Memorials of John Gunn, M.A., F.G.S.: being some Account of the Cromer Forest Bed and its Fossil Mammalia, and of the Associated Strata in the Cliffs of Norfolk and Suffolk, from the MS. Notes of the late John Gunn. With a Memoir of the Author. Edited by Horace B. Woodward, F.G.S., with the assistance of E. T. Newton, F.G.S., F.Z.S. (Norwich: W.A. Nudd, 1891.)

FOR the last half century Mr. John Gunn has been a central figure among the geologists of Norfolk, and the present volume is a welcome addition to the records of work accomplished by local observers, to whom British Geology is so much indebted. At the time of his death Mr. Gunn was occupied with a second edition of his "Sketch of the Geology of Norfolk" (contributed in 1883 to White's History and Gazetteer); and a series of plates illustrating the larger Mammalian remains of the Cromer Forest Bed had already been prepared and printed. The MS. was well advanced towards completion, and, by the expressed wish of the author, it was entrusted to Mr. Horace B. Woodward for publication in whatever form might seem most desirable. Mr. Woodward wisely decided not to reprint the earlier "Sketch," which is already accessible, and would have required much alteration in the bringing up to date; but, with the assistance of Mr. E. T. Newton, he only selected such portions of the Supplementary Notes as contained Mr. Gunn's original observations and opinions. A short Memoir of the Author, with a Portrait, and a summary of his work, have been added to these notes; and the series of plates, with the explanatory remarks, form an interesting guide to the Gunn Collection of Forest Bed Mammals now preserved in the Norwich Museum.

The principal items in the biography of Mr. John Gunn were given in the obituary notice in the Geological Magazine of July, 1890 (pp. 331–333). Mr. Woodward's additional notes on some of his papers, however, are worthy of enumeration. Though chiefly concerned with the later formations, Mr. Gunn paid some attention to the Chalk and underlying rocks; and his opinions concerning the Red Chalk and the possibility of discovering Coal-measures beneath the Secondary strata of Norfolk are worthy of respect. The age and relations of the stony bed at the base of the Norwich Crag received much attention from the author, who was especially interested in the Mammalian remains it yielded; and two important sections (one at Bramerton, the other at Coltishall) are reproduced

[1] O. M. Reis, Geognost. Jahrb. 1890, p. 30.

from his unpublished MS. Long-continued researches in connexion with the Forest Bed series and Boulder-clay eventually led Mr. Gunn into wide speculations as to the cause of the Glacial Period; and in his published "Sketch" he treated of still more recent phenomena, making interesting observations on the growth and accumulation of plants in the Norfolk Broads.

Mr. Gunn's own chapters in the volume before us, as might be expected, relate almost entirely to the Forest Bed series. Even to the last his views as to this formation and some of its fossil Mammalia were not altogether in accordance with those of the latest authors; and a table is added to show Mr. Gunn's classification of the deposits as compared with the schemes of Prof. Prestwich and Mr. Clement Reid. It is of great value to have a permanent record of the observations and conclusions of one who made so prolonged and detailed a study of this much-discussed series; and some new woodcuts help to explain the text. The notes on the Mammalia were evidently only just begun, and are thus confined to a discussion of the so-called *Elephas* (*Leptodon*) *giganteus*, *Cervus bovides*, and *Cervus Cromptoni*. None of these names are adopted by Mr. E. T. Newton, who supplies the latest lists of the Forest Bed and Norwich Crag Vertebrate Faunæ; but it is very satisfactory to have a definite statement by the author of the grounds upon which he founded his determinations.

The little volume of "Memorials" is, indeed, a work of far more than local interest; and we commend it to the notice of all who are occupied in studying the latest phase in the geology of the western border of Europe.

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IV.—Notes on the Geological Section exposed in the Railway Cutting from Levenshulme to Fallowfield. Part I. By Wm. Brockbank and C. E. de Rance. Mem. and Proc. Lit. and Phil. Soc. Manchester, ser. 4, vol. iv. pages unknown, with plate v. in 3 sections: date uncertain, 1891.[1]

In this section the Upper Measures of the Lancashire Coal-field, possibly the highest Coal-Measures known in England, are seen to underly "Lower Red Sandstone" of Permian age. In the present paper the authors describe the eight groups of limestones with associated marls that form the Upper Coal Measures in this locality. The sixth group from the top is considered to correspond with the Ardwick Limestone of Phillips containing *Megalichthys Hibberti*. Most of these Limestones consist largely of Entomostracan and Annelide remains, and contain numerous coprolites, but not many other fossils. The presence of Hematite produces "beautiful gradations of colour" in both limestones and marls, and we are assured that, in the long coloured section given with the paper, the actual tints are reproduced; to dispel doubts excited by the brilliancy of the plates, this assurance is subsequently repeated. The authors

[1] As the Authors' copy, which alone has been sent to us, has been repaged, we are unable to give our readers the correct reference to the original place of publication.

reserve for a future paper the description of the junction of the "Levenshulme Limestones" with the Permian "Collyhurst Sandstone."

## V.—British Fossil Birds.

MR. R. LYDEKKER contributes a valuable article on British Fossil Birds to the July Number of "The Ibis," containing a critical summary of present knowledge of the subject. The article occupies pp. 381–410 of the current volume, and treats in succession the birds of the Superficial Deposits, those of the Pliocene Crags, those of the Upper Eocene (Oligocene), those of the Lower Eocene, and the few fragments from the Cretaceous. The researches undertaken by the author for the recently published "Catalogue of Fossil Birds in the British Museum" form the basis of the Memoir; and it constitutes an important readable addendum to the work just cited (see Review of Catalogue in August No. p. 378).

## VI.—"Pantobiblion: An International Bibliographical Review of the World's Scientific Literature." Edited by A. Kersha, C.E. (St. Petersburg and London: Swan Sonnenschein & Co., 1891.)

WE have received the first number of this new monthly, edited and printed in St. Petersburg, and to be obtained in England from Messrs. Swan Sonnenschein & Co. Nearly 300 pages are occupied with classified lists of new scientific works and periodicals, some of which are briefly reviewed. Under the heading "Geology and Mineralogy" we find recorded several Inaugural Dissertations and small separate publications such as are often overlooked by workers. The new periodical will prove most valuable to all engaged in scientific pursuits, and especially to those dealing with applied science.

## VII.—Monograph of the Fossil Species of *Pristis*. [Monografia dei *Pristis* fossili con la Descrizione di una nova Specie del Calcare miocenico di Lecce.] By Dr. Giovanni Vigliarolo. Mem. R. Accad. Sci. Napoli, [2] vol. iv. append. No. 3, pp. 1–28, with plate. (1890.)

AFTER a definition of the genus *Pristis* and a partially critical synopsis of all known species determined upon the evidence of fossils, Dr. Vigliarolo proceeds to a detailed description of three fragments of a rostrum, from the Miocene of Lecce, preserved in the Geological Museum of the Naples University. The description is illustrated by a large folding plate, and justifies the recognition of a new species, *Pristis lyceensis*. *Sclerorhynchus* and *Propristis* are regarded as extinct genera of Pristidæ, but *Amblypristis* is considered to be merely a synonym of *Pristis*. The known fossils are so fragmentary that they seem to be scarcely worthy the extended treatment they have received at the hands of the author; but the result of his investigations is a useful epitome of our present knowledge of the subject.

# REPORTS AND PROCEEDINGS.

## Geological Society of London.

June 24, 1891.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On Wells in West-Suffolk Boulder-clay." By the Rev. Edwin Hill, M.A., F.G.S.

It might be supposed that in a Boulder-clay district water could only be obtained from above or from below the clay. But in the writer's neighbourhood the depths of the wells are extremely different, even within very short distances; and since the clay itself is impervious to water, he concludes that it must include within its mass pervious beds or seams of some different material which communicate with the surface. It would follow that this Boulder-clay is not a uniform or a homogeneous mass.

The visible sections are only those given, at hand by ditches, and at a considerable distance north and south by pits at Bury St. Edmunds and Sudbury. The appearances in these harmonize with that conclusion. Conclusion and appearances differ from what we should expect on the theory that this Boulder-clay was the product of the attrition between an ice-sheet and its bed.

2. "On the Melaphyres of Caradoc, with Notes on the Associated Felsites." By Frank Rutley, Esq., F.G.S.

Within very limited areas the melaphyres of Caradoc differ considerably in texture and in structure, some having once been basalt-glass or andesite-glass (such being the superficial portions of a lava-stream); others have possessed a certain amount of interstitial glass, which has subsequently been rendered more or less opaque by the development of magnetite, while at times it appears to have been converted into a palagonitic substance. In some of the rocks the crystalline texture is very fine, in others comparatively coarse. Near the summit of Caradoc is a basalt-tuff or andesite-tuff.

The melaphyre or dolerite of Little Caradoc differs from the lavas in that the augite remains fresh and the felspars are altered, while in the lavas of Caradoc proper the pyroxenic constituent is decomposed and the felspars remain as a rule unaltered.

Whether the melaphyre of Little Caradoc may be regarded as a neck from which the lavas lying to the south-west of it emanated, is a point which can only be demonstrated by further field-work.

The author considers that further investigation may prove beyond dispute that the associated felsites are rhyolites of which the original structures have as a rule been almost entirely obliterated. In an appendix further evidence is adduced in favour of the original rhyolitic nature of these felsites, and a fragmental rock from Bowdler's Chair is described as unquestionably a rhyolite-tuff.

3. "Notes on the Geology of the Tonga Islands." By J. J. Lister, Esq., M.A. (Communicated by J. E. Marr, Esq., M.A., F.R.S., Sec.G.S.)

The islands of the Tonga group are situated on a long ridge

which rises from deep water on either side to within a thousand fathoms of the surface of the sea. The general direction of the ridge is N.N.E. and S.S.W.

(1) A line of volcanoes, some active, some extinct, traverses the group. Continued southward, the direction of the line passes through the volcanoes of the Kermadec group, and those of the Taupo zone of New Zealand; while to the north it cuts the line of the Samoan volcanoes at right angles.

(2) Besides the purely volcanic islands there are some formed by submarine eruptions, whose layers have been laid out under water and since elevated, with or without a covering of limestone.

(3) The remaining islands are formed entirely of limestone.

Eua is an example of the second group. The volcanic basis consists for the most part of beds laid out beneath the sea, and some of the upper ones contain pelagic shells. Dykes of augite and hypersthene-andesite project on the shore, and a representative of the plutonic series occurs. There is evidence that the island has been elevated and again submerged prior to the elevation which has raised it to the present height. The volcanic basis is largely invested with limestone, and this rock forms the summit 1078 feet above sea-level. Sections show that it is a shallow-water deposit.

Of the purely limestone structures, Tongatabu, Nomuka, and the long reef on which the larger islands of the Hapaii group are situated, form more or less complete atolls, all of which have been elevated to a greater or lesser extent.

The Vavau group is remarkable for its very indented contour, suggesting the idea that it rests on a much denuded basis. Both here and at Eua there are raised limestone formations with atoll or barrier-like contours; and there is some direct evidence to show that these have been formed without the aid of subsidence.

The presence of islands formed of volcanic materials laid out in layers beneath the sea, and the manner in which the recently formed Falcon Island is now being reduced to the condition of a submarine bank, suggests that the atolls of the group may rest on similarly formed foundations.

4. "On the Inverness Earthquakes of November 15th to December 14th, 1890." By C. Davison, Esq., M.A. (Communicated by Prof. Charles Lapworth, LL.D., F.R.S., F.G.S.)

In this paper the author gives reasons for supposing that the Inverness earthquakes of last year were due to the subsidence of a great wedge of rock included between a main fault and a branch one; and he considers that there is little doubt that these recent earthquakes were the transitory records of changes that, by almost indefinite repetition in long past times, have resulted in the great Highland faults.

The next meeting of the Society will be held on Wednesday, November 11th, 1891.

## CORRESPONDENCE.

### THE SUPPOSED DICYNODONT FROM THE ELGIN TRIAS.

Sir,—At the meeting of the British Association at Aberdeen in 1885, much interest was excited by the alleged discovery of *Dicynodon* in the Triassic sandstones of Elgin. Professor Judd stated his belief in the specimen at the time ("Nature," Oct. 15, 1885, p. 573), and said that the specimen was in the hands of Dr. Traquair. In Woodward and Sherborn's "Catalogue" (1890) I notice these authorities place a (?) before the reference, thus indicating the doubtful nature of the find, while Lydekker in vol. ii. "Manual of Palæontology" does not even refer to it. Are we to interpret Dr. Traquair's six years' silence as a withdrawal of the original determination? When an important discovery has been announced, it seems only just that the geological public should hear more about it, and this practice of throwing out vague and unsatisfactory statements is very annoying to those who prefer exact information and rather disparaging to the discoverer, who naturally expects so great a find to be worthy of notice.

G. Roper.

### ON DYNAMO-METAMORPHISM.

Sir,—I think Dr. Irving has not quite understood the reasoning in my short article on Dynamo-metamorphism of a year ago. I wrote, that the part of the work of compression expressed by the product $(P - W)\,w$, where $P$ is the compressing force upon a cubic element of the disturbed mass, $W$ the weight of the cover, and $w$ the height through which the cover has been lifted, was employed in bending and breaking the rock and overcoming friction, and that, since this part of the energy is not reconvertible into mechanical work, it must take the forms of heat and chemical action. He thinks this "last term is surely outside the others altogether"; that is, I suppose, is employed upon the rock external to the portion of it under consideration. But the expression is not very clear, though his illustration in the note (p. 300) seems to show that such is his meaning. He says there that, if a horse or engine draws a series of loaded trucks along a perfectly horizontal line of rails, "work is done in overcoming the friction of the wheels against their axles and against the rails, and in the displacement of a portion of the atmosphere with the movement of the train; but would any one contend that energy was stored up in the train?"

Energy of motion is so obviously stored up in the train that Dr. Irving cannot refer to that. He must refer to the energy imparted to the atmosphere, and to the energy absorbed by friction, which last is distributed between the trucks and the rails. The energy communicated to the air is "outside" the other effects, and so is the energy absorbed by the rails. But the energy absorbed by the friction of the wheels against their axles is partly converted into heat, and is partly employed in producing a molecular change in the iron, rendering it more granular and liable to fracture. I should consider this a case of dynamo-metamorphism. Still it appears to

me that the illustration is not apt. The amount of work to which I refer must be expended on bending and breaking the *particular mass* of rock under consideration, and in shearing the parts of it past one another, and not on the rock outside of it. Hence the energy which is its equivalent has been introduced into the mass; and, energy being indestructible, none of it is lost, and there is now more energy in the mass than there was before. The question which I proposed was simply, what form does that energy take? Is it heat? or is it, as I (perhaps rashly) enquired, chemical energy?

Dr. Irving says that both Mr. Harker and myself have overlooked the one great factor of metamorphism, viz. superheated water. I do not think we either of us proposed to discuss all the causes of metamorphism, but only the mechanical. O. Fisher.

Harlton, Cambridge, 11 *July*, 1891.

## DYNAMO-METAMORPHISM AGAIN.

Sir,—A short space will suffice for what I have to say in reply to Dr. Irving (p. 296). I am sorry to have misunderstood, or, as he phrases it 'misrepresented,' him as assuming that the whole of the work passes into heat. I am not sure that even now his position is clear to me. His dictum "chemical combination must generate heat" is intelligible, though, as Mr. Fisher has pointed out, by no means universally accepted by chemists; but simple combination does not cover any of the chemical changes that characterize the metamorphism of rocks. These are "much more complex," and if Dr. Irving believes that in these cases there is always, on the balance, a positive amount of heat generated, he believes that for which no proof whatever is offered.

It is possible that some of the differences between Dr. Irving and myself would resolve into a question of words. if his language were more intelligible to me; but unfortunately his usage of physical terms often bears no relation to the definitions in use among physicists. "Intensity of heat" seems to mean temperature, but what are we to make of the expression (used in taxing another correspondent with confusion of thought) "the energy is presented in the mechanical form of pressure"? The simple word 'deformation' also appears to be employed in some occult sense.

The experiments of Cailletet and Pfaff which I cited are the same as those referred to in the "Report on Slaty Cleavage" mentioned by Dr. Irving. They seem to establish that increased pressure retards chemical changes involving a diminution of density, while Spring's researches tend to show that pressure assists changes involving an increase of density. The two conclusions appear to me not contradictory, but complementary parts of one law. As regards Spring's experiments, Dr. Irving has ludicrously misunderstood me when he implies that I deny the generation of heat by friction during the compression. What I said was that the heat so generated was carefully removed (by conduction). As Major-General McMahon points out (at p. 90 of this volume), M. Spring himself seems to have changed his views as regards the significance of his work, but

the published details of his experiments leave others free to draw their own conclusions from them. Kroustchoff's interesting synthetic production of hornblende and other minerals do not seem to throw any new light on the problems in hand.

ALFRED HARKER.

## OBITUARY.

### DANIEL MACKINTOSH, F.G.S.

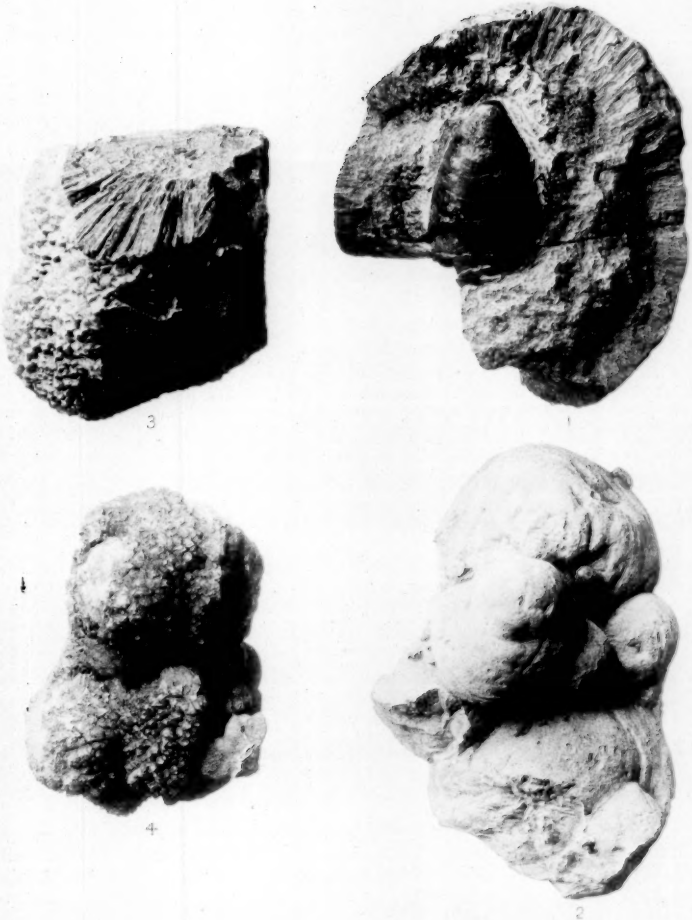
BORN 1815. DIED 19 JULY, 1891.

WE regret to announce the death of Mr. Daniel Mackintosh, F.G.S., who was born in the memorable year 1815, at Blairgowrie, in Perthshire, where his father had a mill worked by water-power. Imbued with an early love of Natural Science, he left Scotland when about 30 years of age. For many years he was a lecturer on Scientific subjects and well known in the south of England, where he lectured at various public institutions and schools on Astronomy, Geology, Physical Geology and Ethnology with considerable success. His manner as a lecturer was clear and spirited, and aroused an interest in the subjects of which he treated.

Mr. Mackintosh was elected a Fellow of the Geological Society in 1861, and contributed his first paper on "Terminal Curvature" in 1867, and afterwards numerous papers to the Society on Surface Sculpture, Denudation, Drift Deposits and the Dispersion of Erratic Blocks. Many of his papers are in the "Reports of the British Association," and the "Proceedings" of Societies of which he was a member. He was a frequent contributor to the GEOLOGICAL MAGAZINE, and other scientific publications.

In 1869 Mr. Mackintosh produced his work on "The Scenery of England and Wales," in which he favoured the action of the sea as the greatest denuding agent, and it is illustrated by 86 sketches of geological interest. He received four successive grants in aid of Original Scientific Research, from the Government Grant of the Royal Society. In 1881, he was presented with the Kingsley Memorial Medal of the Chester Society of Natural Science, and in 1886 was awarded the proceeds of the balance of the Lyell Fund by the Geological Society, in recognition of his studies of the Glacial and other Superficial Deposits of the north-west of England.

About 20 years ago Mr. Mackintosh went to reside at Chester, but a few years after he settled in Birkenhead, and was president of the Liverpool Geological Society during 1881–3. In recent years he devoted much time to the examination of the Drift Deposits and Boulders of North Wales, and during his last exploration ascended Cader Idris when nearly 70 years of age. Soon after he began to fail in both mind and body, and died on the 19th of July last, and his remains now rest in Flaybrick Cemetery, Birkenhead, close to the glaciated areas he so frequently visited and described. His papers on the Glacial Deposits will hold a permanent place in geological literature, and he will be remembered for his kind and gentle disposition by all who came in contact with him.—G. H. M.



CONCRETIONS

FROM THE

MAGNESIAN LIMESTONE OF DURHAM.